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Conducted by MAJOR B. BADEN-POWELL and E. S. GREW, M.A.

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Our Stellar Universe.

By T. E. HEATH.

IT is related by Campbell that Sir William Herschel told him he had observed stars the light of which must take two million years to reach this earth. Did Herschel grasp what this meant? It is supposed his reflector could show stars to the 15th magnitude; if so, he might have seen a star the light of which had been travelling for two million years, provided it gave 438,000 times as much light as our Sun.

Professor Seeliger thinks our Stellar Universe is in shape like a thick lens, and estimates the nearest parts of the Milky Way are about 4,400 light-years distant, and the most remote about 9,700. Other astronomers appear to have very vague ideas as to its limits. Some estimate its probable radius at from 10,000 to 30,000 light-years. Few seem to have checked their conclusions by considering what the sun-power of stars at the supposed boundary would be.

I have drawn a section of our Stellar Universe of the shape which Professor Seeliger's statistics of stellar density seem to require, but I have not adopted his dimensions. The maximum size I think probable in light-years is indicated by circles struck from what appears to be the most likely present position of the Sun. The drawing pretends to no accuracy of stellar distribution, save that I have, very roughly, made the stars congregate about the Galactic Zone and the nebulæ about its poles. So far astronomers are agreed, but for the rest some think the stars thin out, others that they get more numerous towards the boundary. Probably the Milky Way is very much what it appears to be, a congregation of stars, clustering here, separating there; irregular forms and masses such as we see in Spiral Nebulæ; nearer to us in parts, more distant elsewhere, but lying generally in a great circle round us. There seems to be no reason for thinking the thickness is greater than the lateral extension; indeed, the rifts and openings give the opposite impression.

I remember how thirty or forty years ago most of the stars were supposed to be almost infinitely distant, but yet revolved in some mysterious way round Alcyone. No one did more by star-charting and lecturing to change the general opinion about the Visible Universe than Richard Proctor. His equal surface chart of 324,000 stars to about 9th magnitude shows the chief features of the Milky Way and even the wonderful complexity of its interior structure. He says it has on it 1,115 lucid stars, and it covers 9 per cent. of the sky; the gaps in the Milky Way cover 1.6 per cent. and have on them only 20 lucid stars, whilst the remaining 89.4 per cent. of the sky has on it 4,715 lucid stars. He concludes the 640 stars in excess of normal density which we see upon the Milky Way are actually in it. Professor Newcomb has shown that the circle of the Milky Way can be found within 5° of its true position by the clustering of lucid stars alone, and proved that about 70 per cent. of stars up to 6th magnitude and about 140 per cent. up to 7th magnitude, which appear to be on the Milky Way, are in it.

Possibly there are no stars in the Milky Way greater than the 3rd or 4th magnitude, and but few of them; of the 5th there would be more, of the 6th a considerable number, and of the 7th and 8th very many thousands. According to Professor Kapteyn, in any group of 15,000,000 stars, 13⅓ per cent. would be about one sun-power each, 3⅓ per cent. would be more, and 83⅓ per cent. would be less. If this be true, from what we know of the probable number of stars of each magnitude (see Mr. Gore's estimate, "KNOWLEDGE," 1901, page 178), a star of one sun-power at the Milky Way's average distance would appear about the 12th or 13th magnitude.

Assuming the Sun's magnitude is −26.4, I worked out his magnitude at different distances in light-years; they come thus, at 479, 11th magnitude; at 759, 12th; at 1,210, 13th; at 1,910, 14th; at 3,020, 15th; at 4,790, 16th; at 7,590, 17th; at 12,100, 18th; and at 19,100, 19th magnitude.

Now there are very few 18th magnitude stars, and it is doubtful if there are any 19th, but it will be seen that if the Sun were removed to Professor Seeliger's estimated mean distance of the Milky Way (viz., 7,550 light-years), he would be reduced to the 17th magnitude. There may be 20 or 30 per cent. of the Milky Way stars as small as this, but they are certainly nothing like 83 per cent. smaller.

Professor Newcomb writes that "the bluest and most luminous stars are situate mainly in the regions of the Milky Way," but apparently he comes to this conclusion because he thinks the Milky Way begins beyond a distance of 1,300 light-years, and considerations based upon proper motions lead him to place these stars even beyond the sphere of 3,260 light-years.

Proctor thought the Milky Way stars are for the most part small.

It seems not unreasonable to suppose that for any considerable group of stars, such as the Milky Way, we can make the best estimate of probable distance by assuming that none of them are much more luminous than the giants of the same class we have measured, and that they contain a fair proportion of the stars of all sizes we have discovered in the only space sphere at all thoroughly surveyed (that of 15 light-years radius).

XUM

In my "Road-Book to the Stars" I asked for corrections and additional data. Mr. Gore kindly sent me the paper on the "Relative Brightness of Stars," which he communicated (January, 1905) to the Royal Astronomical Society. In this he only gives stars for which he thinks the parallaxes are fairly good; those most reliable he marks (*), whereas in my "Road-Book" I gave all the estimates I could collect. So far as Mr. Gore's list goes my distances agree with his; I have now in the list for 1st magnitude stars herewith put (*) to the distances he considers most reliable, and (?) against those he does not give at all. Otherwise the light-years remain as in my book. Mr. Gore has taken the Sun's magnitude as – 26.5, whereas I took it as – 26.4; so that, other things being equal, where he called the relative brightness of a star 1,000, I should call its sun-power 1,095.

Mr. O. R. Walkey also has sent me a long and very interesting account of his method of getting at the Absolute Parallaxes for all the 1st magnitude and some other stars. Only he himself could do justice to his method, but I give his absolute parallaxes and sun-powers. (He takes the Sun's magnitude as – 26.4.) If Canopus is, as he thinks, of 71,880 sun-powers, and if the surface brightness is the same as the Sun's, the Sun might be situate at the centre of Canopus, the earth would revolve about 22 million miles below its surface, and we should find it quite unpleasantly hot.

In the following list I have divided the first magnitude stars into two classes: the first, Orion, type O, Sirian, type I, and Procyon, type I-II. The second, Solar, type II, and Autarean, type III. Parallaxes observed at the Cape are marked C, at Yale, Y. The magnitudes are revised Harvard.

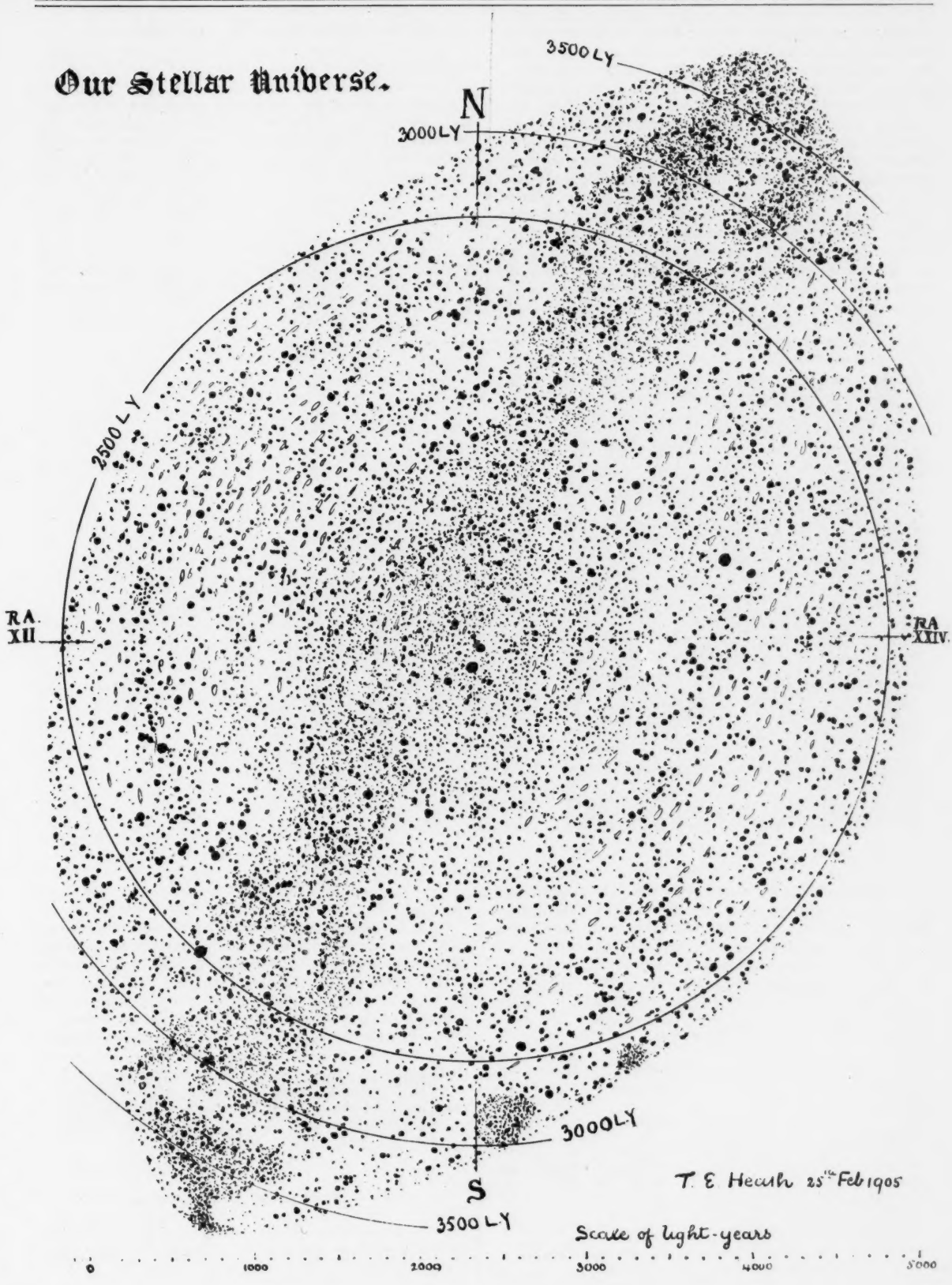
In the Appendix to my "Road-Book to the Stars" I give all the data as to other magnitudes I could collect, but they are too few to enable me to work out, correctly, the average distances and sun-power for each type and magnitude. Estimates may, however, be made from Professor Kapteyn's formula derived from parallactic motions. Professor Newcomb has done this in his book on the "Stars," doubling the distance every two magnitudes, but Mr. O. R. Walkey has corrected his parallaxes by going carefully through Kapteyn's original work. From these corrected parallaxes I have worked out the distance in light-years and the sun-power for each type and magnitude. *The results, if they can be relied upon as averages* (not, of course, for individual stars), *are of great importance.*

	Type I.				Type II.		
Mag.	Light-Years.		Sun-Power.		Light-Years.		Sun-Power.
2	139	—	333	...	61	—	64
3	185	—	236	...	81	—	45
4	247	—	167	...	109	—	32
5	329	—	118	...	144	—	23
6	438	—	84	...	193	—	16
7	587	—	60	...	257	—	11
8	779	—	42	...	341	—	8
9	1041	—	30	...	457	—	5·7
10	1392	—	21	...	609	—	4
11	1845	—	15	...	812	—	2·9

The average sun-power for the first magnitude we have found to be 3,132/8,965 for type I, and 529/397 for type II. Far beyond the second magnitude! From the second down the sun-power is halved every two magnitudes—*the further we go the smaller is the average size!* But in my "New View of the Stars" I show that in the only space-sphere thoroughly surveyed, the percentages are as follows:—24 of 1 to 36 sun-

Star.	Type.	Magnitude.	Parallax (Relative.)	Error. ±	My "Road-Book." Light-Years.	My "Road-Book." Sun-Power.	Mr. Gore's Relative Brightness.	Mr. Walkey's Estimates for Absolute Parallax.	Mr. Walkey's Estimates for Light-Years.	Mr. Walkey's Estimates for Sun-Power.
			"	"				"		
Sirius	I	– 1·58	C ·370	·005	* 8·8	36	33	·377	8·64	35
Canopus	I-II	– 0·86	C ·000	·010	? 296	21357	—	·006	543	71880
Vega	I	+ 0·14	Y ·082	·016	39·7	154 a	139	·090	36·2	127
Rigel	O	0·34	C ·000	·010	? 367	11025 a	—	·006	543	23800
Procyon	I-II	0·48	Y ·334	·015	* 10·2	7·6	6·49	·335	9·73	6·7
Achernar	O	0·60	C ·043	·015	? 76	362 a	—	·045	72·4	333
β Centauri	O	0·86	C ·030	·015	? 108	605	—	·036	90·5	410
Altair	I	0·89	Y ·232	·019	* 14·2	9·6 a	8·79	·239	13·6	9
α Crucis	O	1·05	C ·050	·019	65·2	183	166	·044	74	230
Spica	O	1·21	C ·000	·020	? 326	3844 a	—	·010	326	3845
Fomalhaut	I	1·29	C ·130	·014	25	21	18·9	·133	24·5	20
α Cygni	I	1·33	Y – ·012	·023	? 271	2565	—	·004	815	21520
Regulus	O	1·34	Y ·024	·020	148	700	642	·031	105	355
β Crucis	O	1·50	C ·000	·008	? 326	2981	—	·010	326	2944
First Class 14 Stars average		0·60	·0219	·015	149	3132		·0153	213	8965
			"	±				"		
α Centauri	II	0·06	C ·752	·010	* 4·34	1·96	1·79	·757	4·3	1·9
Arcturus	II	0·24	Y ·026	·017	136	1648 a	1486	·034	95·8	950
Capella	II	0·21	Y ·079	·021	* 40	146	128	·087	37·5	128
At maximum		0·34						At maximum		1047
Betelguese	III	0·94	Y ·024	·024	? 142	933	—	·029	112	—
Aldebaran	II	1·06	Y ·109	·014	* 30·5	39	35	·116	28·1	33
Pollux	II	1·21	Y ·056	·023	? 58	118	—	·066	49·4	88
Antares	III	1·22	C ·021	·012	? 155	820	—	·027	121	533
Second Class 7 Stars average		0·64	·040	·015	81	529		·051	63·7	397

N.B.—Some of my sun-powers (marked a) are slightly altered from those given before owing to corrected magnitudes.


Our Stellar Universe.
N
3500 LY
3000 LY
2500 LY
RA XII
RA XXIV
3000 LY
S
3500 LY
T. E Heath 25th Feb 1905
Scale of light-years
0
1000
2000
3000
4000
5000

powers, 29 averaging 0.23 sun-powers, 19 averaging .034 sun-powers, and no less than 28 averaging only .005 sun-powers. The majority are dwarfs: it is quite as necessary to provide for dwarfs as for giants in the Milky Way, but there appear to be very few stars of less than the 17th magnitude! The highest authority on this point, the late Dr. Isaac Roberts, writing in "KNOWLEDGE" (1901, page 11) about a photograph of the Milky Way, which shows stars down to the 17th magnitude, says, "The evidence of photographs strongly indicates that those vacant places which appear after exposures of 7 to 12 hours are really void of stars, because exposures of only 90 minutes show the same stars down to the faintest magnitudes." His remarks should be read *in extenso*, as they are more conclusive than thus condensed.

To enable my readers to weigh for themselves the value of the evidence given here, in my first article and in my "Road-Book," I worked out a table which gives the sun-power of stars of different magnitudes at different distances. I think it comprehends all the Milky Way stars, but it can be readily extended up or down, or right or left, *e.g.*, 3rd magnitude, at 1,000 light-years = 6,800 sun powers; or 6th magnitude at 100 light-years = 4.37 sun-powers.

From the evidence produced, my readers can judge as well as I—some better—what are the probable dimensions of our Stellar Universe. The first magnitude stars are exceptionally large, and if they only are considered, and if Mr. Walkey's estimates be correct, we might allow a radius of about 5,000 light-years for the Milky Way, but if 80 per cent. of the stars are smaller than the Sun, the radius would not be more than about 1,500 light-years. I have assumed in my drawing the truth lies between these extremes. I claim to be no authirity in such matters, but seek only to illustrate by my diagrams and stereograms such data as I can collect, so that anyone can see what they mean. The scale I discovered, which, taking the Sun's mean distance as one inch, makes the distance travelled by light in one year one mile, is, I find, to most people, a real help. Objects in space of three dimensions can be drawn without distortion as well upon a flat surface as upon a sphere. The excellent maps now being published in "KNOWLEDGE" appear to have no distortion if they are viewed with a lens so that the eye is $5\frac{1}{8}$ inches above the centre. It is greatly to be desired that some owner of a clock-driven telescope would take and publish a set of lantern slide star maps (which could be enlarged as required), using a stigmatic lens of $3\frac{1}{4}$ inches focus and short exposure, so as not to go much below the 6th magnitude.

SUN-POWERS OF STARS AT DIFFERENT DISTANCES.

Magnitude of Star.	L.Y. 1,000	L.Y. 1,500	L.Y. 2,000	L.Y. 2,500	L.Y. 3,000	L.Y. 3,500	L.Y. 4,000	L.Y. 5,000	L.Y. 6,000	L.Y. 7,000	L.Y. 7,500	L.Y. 8,000	L.Y. 9,000
	S.P.	S.P.	S.P.	S.P.	S.P.	S.P.	S.P.	S.P.	S.P.	S.P.	S.P.	S.P.	S.P.
4	2,700	6,080	10,800	16,900	24,300	33,100	43,300	67,600	97,300	132,500	152,900	172,800	218,700
5	1,140	2,550	4,550	7,060	10,200	13,900	18,200	28,200	40,800	55,700	64,000	76,900	91,800
6	437	980	1,750	2,720	3,920	5,330	7,000	10,900	15,700	21,200	24,500	28,000	35,300
7	175	392	700	1,090	1,570	2,130	2,800	4,360	6,280	8,540	9,900	11,200	14,100
8	68	154	272	428	615	840	1,090	1,710	2,460	3,560	3,840	4,360	5,530
9	27	60	108	169	243	330	433	676	973	1,325	1,529	1,728	2,187
10	11·4	25·5	45·5	70	102	139	182	282	408	557	640	769	918
11	4·4	9·8	17·5	27	39	53	70	109	157	212	245	280	353
12	1·7	3·9	7·0	11	16	21	28	44	63	85	99	112	141
13	0·7	1·5	2·7	4·3	6	8	11	17	25	36	38	43	55
14	0·27	0·6	1·08	1·7	2·4	3·3	4·3	6·8	10	13	15	17	22
15	0·11	0·25	0·45	0·7	1·02	1·4	1·8	2·8	4·1	5·6	6·4	7·7	9·2
16	0·04	0·10	0·17	0·27	0·39	0·5	0·7	1·1	1·6	2·1	2·4	2·8	3·5
17	0·02	0·04	0·07	0·11	0·16	0·21	0·28	0·44	0·63	0·85	1·0	1·1	1·4
18	0·007	0·015	0·027	0·04	0·06	0·08	0·11	0·17	0·25	0·35	0·38	0·4	0·5
19	0·003	0·006	0·011	0·017	0·024	0·033	0·04	0·07	0·10	0·13	0·15	0·17	0·2

Dr. Easton in an interesting article ("KNOWLEDGE," 1903, page 154) gives a sample of the Milky Way (area $\frac{1}{50,000}$ part of sky). He has estimated magnitudes (from 5.2 to 14) of the 1,761 stars shown therein.

To help our judgment I worked out the sun-powers for these stars, upon the supposition they are either 1,500, or 3,000, or 7,500 light-years distant. They come out as follows:—

Average Mag.		1500 L.Y.		3000 L.Y.		7500 L.Y.
5·2 —	1 Star	= 2075 S.P.	...	8300 S.P.	...	52,900 S.P.
7·8 —	1 "	= 225 "	...	900 "	...	5,730 "
8·3 —	6 "	= 120 "	...	480 "	...	3,060 "
8·8 —	6 "	= 80 "	...	320 "	...	2,040 "
9·3 —	17 "	= 51 "	...	205 "	...	1,300 "
9·8 —	42 "	= 33 "	...	132 "	...	840 "
10·3 —	61 "	= 20 "	...	81 "	...	516 "
10·8 —	103 "	= 12·5 "	...	50 "	...	318 "
11·3 —	135 "	= 8 "	...	32 "	...	204 "
11·8 —	134 "	= 5 "	...	20 "	...	130 "
12·3 —	141 "	= 3·25 "	...	13 "	...	84 "
12·8 —	188 "	= 2 "	...	8 "	...	51 "
13·3 —	229 "	= 1·25 "	...	5 "	...	32 "
13·8 —	697 "	= 0·75 "	...	3 "	...	20 "

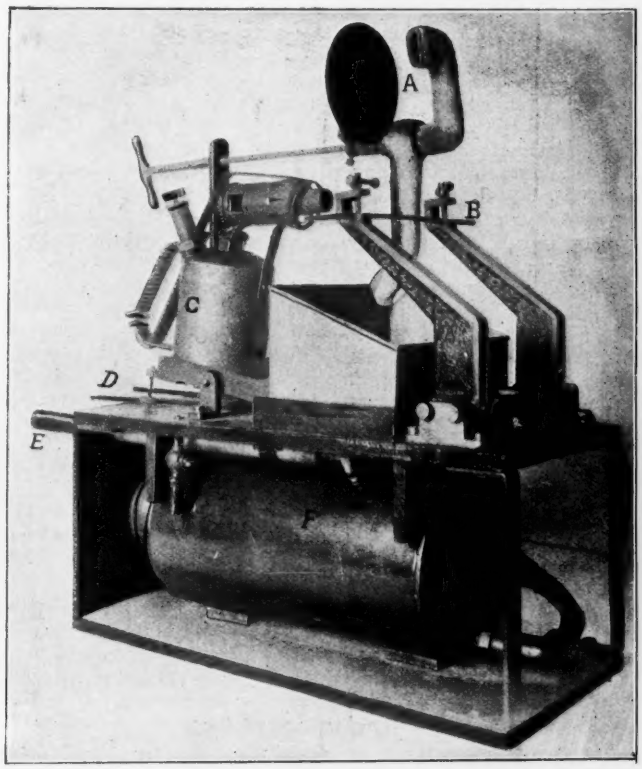
In my first article I suggested a model which would show the Sun and stars of estimated parallax shining with proportionate luminosities. I have constructed such a model more efficiently than I had hoped, and upon convenient flat surfaces, in the six large stereograms I recently exhibited in London. I may even say that when I took the members of three learned societies many hundred billion miles out into space and showed them the Sun and stars shining in their proper colours, with their relative luminosities and hanging in space at their estimated distances, I broke through the crystalline vault which has so long imprisoned even those who know it is but an illusion.

Notice to Readers.

WE beg to remind regular subscribers that the Special Number, to be published on July 15th, will run concurrently with the usual numbers, the paging being continuous, and the matter will be included in the index for the year.

A New Process for Welding Aluminium.

THE Cowper-Coles process for welding aluminium requires no flux, and does not necessitate the hammering of the joint when in the semi-fluid state. The process is especially suitable for wire rods and tubes and other drawn or rolled sections, and consists in placing the parts to be welded, after being faced off square, in a machine (illustration No. 1), fitted with clamping



Cowper-Coles's Machine for Welding Aluminium.
A, Screen; B, Aluminium Rods; C, Lamp; D, Levers for applying pressure; E, Pump; F, Water Reservoir.

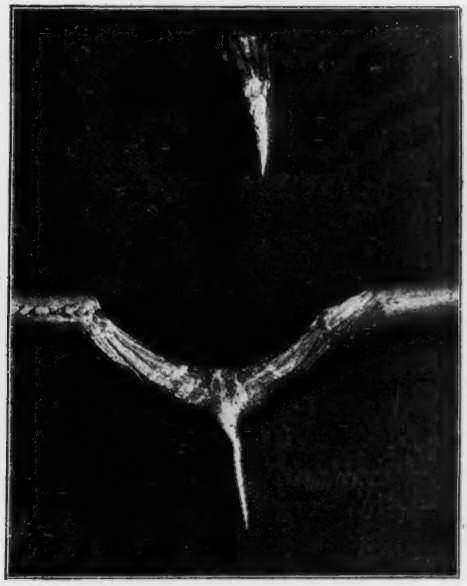
screws, which are capable of moving horizontally on guides; the movement of the clamping screws is controlled by the levers D. The aluminium to be welded is heated by means of an ordinary benzine lamp. As soon as the rods have arrived at the necessary temperature, slight pressure is applied to the levers D, which causes the aluminium rods to unite, and a ring of metal is squeezed out, as shown in illustration No. 2. This

Joint after Welding.

ring is largely composed of aluminium oxide, and acts as an insulating and supporting collar, the molten metal being retained within this collar. The weld is then instantaneously quenched by turning a handle attached to the screen A, which allows water, under pressure, to be projected on to the joint from the reservoir F. The same handle which turns the water on, places the screen A in front of the heating flame. The water pressure is maintained by air supplied by the hand pump E. The rod is finally removed from the machine and the collar filed off, when it will be found that the joint is as strong as the rest of the metal. An oxygen-hydrogen flame or ordinary gas with or without air can be substituted for the benzine lamp. The process is a simple one, and can be worked by any unskilled workman.

Illustration No. 3 clearly shows the molten aluminium supported by a pipe or case of aluminium oxide, the case having been pricked with a steel point to allow some of the molten metal to flow out.

The following table gives the result of tests for tensile strength on twelve consecutive welds (not picked specimens) made by the process just described. The fractures occurred at a con-



siderable distance from the weld, showing that the metal has not deteriorated at the weld. In the twelve tests referred to, not one specimen broke through the welded portion.

Dimensions.	Area.	Reduction of area at fracture.	Extension. on 4 in.	Extension. on 2 in. at fracture.	On Original Area. Elastic Limit (Yield Point). Pounds.	Tons	Maximum stress. Pounds.	Tons	Remarks.
	Square inches.	Per cent.	Per cent.	Per cent.	Per square in.		Per square in.		
Diam. in.									
0·249	0·0487	7·4	8·0		11491	5·13	20249	9·04	Broke outside datum points.
0·248	0·0483	7·4	13·0		8803	3·93	22265	9·94	Ditto
0·254	0·0507	7·5	8·0		11043	4 93	19868	8·87	Ditto
0·252	0·0499	7·4	11·7		14358	6·41	16150	7 21	Ditto
0·252	0·0499	7·7	13·0		21996	9·82	21996	9·82	Ditto
0.250	0·0491	7·6	9·0		14134	6·31	19622	8·76	Ditto
0·250	0·0491	7·7	9·0		14134	6.31	14134	6·31	Ditto
0·254	0·0507	7·9	11·0		15030	6·71	24304	10·85	Ditto
0·251	0·0495	7·8	7·8		14940	6·67	20361	9·09	Ditto
0·253	0·0503	7·7	14·0		10236	4·57	19152	8·55	Ditto
0·250	0·0491	7·7	9·0		12320	5·50	20070	8·96	Ditto
0·247	0·0479	7·7	9·0		8422	3·76	18704	8·35	Ditto

The Nature of Life.

By GEOFFREY MARTIN, B.Sc. (LOND.).

II.

Now the temperature and pressure on the world's surface have not always remained exactly the same as they are at present. Indeed, it is probable that the further we go back, the higher was the temperature conditions which held upon the world's surface. Probably, indeed, at the earliest times, the world's surface was a white hot fluid mass surrounded by vast masses of vapour. Consequently, in very early times, if living matter existed, its structure must have been quite different to that which it has at present. And the further we go back, the greater must have been the difference between the structure it possessed then and the structure it possesses now. For at ordinary temperatures and pressures, living matter contained the exact quantities of the necessary elements (namely, carbon, hydrogen, nitrogen, oxygen, sulphur, and phosphorus) to make its critical temperature of decomposition coincide with the conditions which hold upon the earth. And as the temperature and pressure of the world altered, the relative quantities of these elements entering into the structure of living matter would also have to alter in order to make its critical temperature and pressure coincide with the new temperatures and pressures.

The higher the temperature and pressure, in general, the greater would be the tendency to let heavier and less volatile elements enter into its structure, and at the highest temperatures and pressures, living matter, if it existed at all, must have been composed out of altogether different elements to those which at the present time enter into its structure.

I would, in fact, suggest that the structure of living matter has, like most other things, undergone a continuous process of evolution (and is still undergoing it) with the changing external conditions, and that at the time when the earth was a white hot fluid sea, life still existed in a form quite different to that which it now nossesses; that the chief elements entering into its structure were at that time heavy non-metallic elements, such as silicon, sulphur, phosphorus, and oxygen; and that as the world gradually cooled, the heavier elements were gradually eliminated and the lighter elements took their place by a natural process of circulation, until finally the composition of living matter assumed its present one.

Now is there any element which could play at high temperatures in living matter the part played therein at ordinary temperatures by carbon? Silicon is such an element. Silicon, like carbon, possesses a high and constant valency, has a very considerable capacity for self-combination, and is capable of giving rise to an enormous number of very complex bodies—the silicates and their derivatives—which well vie in complexity with the most intricate carbon compounds. The fundamental difference between the two sets of compounds is essentially one of temperature, the carbon compounds being at ordinary temperatures much nearer their melting and decomposing points than the silicates.

Seeing that the temperature whereat carbon gives rise to protoplasm is at a temperature at which most of its compounds with hydrogen, oxygen, and nitrogen are (probably on account of their instability; see the author's work, "Researches on the Affinities of the Elements," pp. 120-123) in a fluid or semi-fluid state, we should expect that the most suitable temperature for silicon to give rise to an unstable compound would be the temperature whereat the silicates are unstable and, therefore, in a fluid or semi-fluid state—that is to say, at a white heat. Have we any evidence to support the view that living matter did not start originally with carbon, hydrogen, oxygen, and nitrogen as its fundamental elements, but started with elements of far higher atomic weights, such as silicon, phosphorus, sulphur, and oxygen, of which only vestiges now remain in the protoplasm? In this connection it must be remembered that our evidence could be only indirect. For such life might have flourished to an enormous extent in the molten sea of siliceous matter which covered the earth's surface in bygone ages, and yet have left no traces of its existence behind; for when such forms of life died, their bodies would but blend again into the molten rock, in the same way that a jelly-fish dies and blends again into the ocean of salt water, without leaving a vestige behind to show that it has been and gone. Except under exceptional circumstances, organised matter, when dead, very quickly disintegrates.

However, many remarkable siliceous minerals exist—for example, the mineral "Asbestus" or mountain leather—whose peculiar fibre-like structure may be due to its previous organic nature in bygone ages. Again, in some of the most rudimentary forms of organised existence—for examples, the diatoms and sponges—silica still remains in considerable quantities.

Now it is clear that in consequence of the progressive cooling of the earth, the range of temperature at which silicon possesses the capacity for forming the central element of living matter would soon be passed, and hence its complexes would solidify out into stable masses, thus causing all life to cease.

But if carbon entered more and more fully into the composition of living matter, and the silicon as steadily solidified out as the cooling continued, the critical temperature of decomposition (or temperature whereat life is possible) would become progressively lower in proportion as the amount of carbon in the organism increased, and hence the cooling of the surrounding medium, and the alteration in the living temperature of the organism, would proceed together and keep pace—the temperature of the organism lagging slightly behind the falling temperature of the surrounding medium—as it actually does now in world life. The silicon age would thus blend imperceptibly into the carbon age, and when the modern thermal conditions were attained, the carbon would long since have replaced completely the silicon in living matter, and the last era of organic existence would have been entered upon.. I believe that silicon once completely replaced carbon in matter living at a white heat, but that at ordinary temperatures it has been completely replaced by carbon, and remains now merely in certain forms of life as an inactive sediment solely because it can be put to a useful purpose by imparting rigidity to the frame. In cases where it serves no such purpose it has been already completely eliminated; for example, in animal protoplasm only minute traces remain; on the other hand, in grasses and diatoms very large quantities of silicon still exist.

Just as water, the mother liquid in which modern protoplasm first throve, enters to a very large extent into its composition; so also we should expect that

silica of the molten earthy sea would also enter very largely into the composition of the life which flourished at the time when the earth's surface was a red or white hot mass of molten rock. Let me now quote some other facts which make it probable that as the thermal conditions of the earth altered there was a corresponding alteration in the composition of living matter, the denser and less volatile elements steadily solidifying out and their places being filled by analogous lighter and more volatile elements.

Albumen contains a small quantity of loosely-bound sulphur which does not appear to be a very intimate constituent of it. No one knows the function of this sulphur; according to my theory it is simply lingering on, the relics of a time when it almost entirely replaced oxygen in the organism. As the temperature of the living matter fell, the sulphur was superseded by the lighter and more volatile oxygen, and consequently the sulphur which remains is merely an inert mass in the process of elimination, separating out on account of its heaviness, in exactly the same way I have supposed silicon to have separated out in previous ages.

Much the same applies to phosphorus in the tissues of the brain and nerves. It has almost entirely been replaced by the lighter and more mobile nitrogen. The small amount of phosphorus remains mainly because it can perform functions of which nitrogen is incapable. Not only is this so, but traces of a still heavier member of the same group of elements—arsenic—have been recently found in certain animals, where it partially replaces the phosphorus in nucleinic matter.*

In these cases, then, we have a whole chain of chemical analogous elements replacing each other in continually decreasing amounts as they increase in heaviness. Thus :—

Nitrogen	(at wgt. 14)	abundant.
Phosphorus	(at wgt. 31)	less abundant.
Arsenic	(at wgt. 75)	minute traces.

Oxygen	(at wgt. 16)	abundant.
Sulphur	(at wgt. 32)	less abundant.
Selenion	(at wgt. 79)	minute traces, if at all.

Carbon	(at wgt. 12)	abundant.
Silicon	(at wgt. 28)	traces.

These facts favour our supposition that the presence in protoplasm of elements having a high atomic weight are the links which connect the gradually-evolved protoplasm of to-day with the molten minerals of the past. It is very probable, I think, that in many cases formerly abundant elements have ceased to perform any vital function and solely remain as witnesses to the process of evolution, much as the gills on the neck of an embryonic babe bear witness to the aqueous origin of its ancestors. In some cases, perhaps, they are retained on account of the fact that they can be put to useful purposes by being substituted for their lighter chemical analogues, in order to modify the functioning of certain definite organs by reason of certain specific needs. Such would be selenion in place of sulphur; negative sulphur substituted for oxygen; Cu, Zn, or Mn replacing iron; P, As, or even Va itself playing the part of nitrogen in the atomic complexes which make up protoplasm. The whole problem of the secretion of mineral matter by living beings is ably explained by supposing the mobile protoplasm of to-day evolved in a continuous matter from the molten minerals of the past.

By adopting this conception the range of world life would widen magnificently out from the few billion years of Lord Kelvin to countless billions of years, when the world was a white hot globe and its surface a sea of rolling fire. From first principles, indeed, it is very improbable that life could exist only within such narrow limits of temperature and pressure such as are at present prevalent upon the earth. Out of the almost infinite time which has passed before the world cooled to its present state, and the ages that still must run ere the world reaches the absolute zero of temperature, is it to be imagined that during an only infinitesimal portion of this time could organised life exist? To assume this is to place oneself in the position of those early astronomers who held that the sun and stars and the infinite universe itself revolved about the earth as centre.

Again, are we to assume that out of an unknown, but probably enormous, number of elements, only some four namely, carbon, hydrogen, nitrogen, and oxygen, are capable of producing vital matter? When we study the properties of these four elements and compare them with those of other known elements we find that there is absolutely nothing which inherently distinguishes them from the other elements. Every property possessed by them is shared to a greater or less extent by the other elements also. Why, then, should we imagine that only these four elements can give rise to living matter? Why they enter so largely into the constitution of living matter upon this earth is probably a pure accident of temperature and pressure. They merely happen to possess the proper degree of volatility and the capacity for exerting chemical forces of the requisite intensity, which make them somewhat more adapted than the other elements to enter into the constitution of living matter under those particular temperature and pressure conditions which hold upon the earth. But we know that the chemical properties exhibited by an element alter very considerably with the temperature and pressure conditions under which it is viewed. Indeed, it has been suggested* that by altering the external conditions upon which we view an element, we can make it assume in succession the various chemical conditions which the various other elements find themselves in at ordinary temperatures and pressures. If this be so, it is difficult to avoid the inference that under other external conditions, other elements would so change their nature as to become capable of entering into the structure of living matter, although under ordinary temperatures and pressures they are quite incapable of so doing.

Sweeping through space are myriads of vast planets, countless swarms of mighty white hot globes and dark suns, whose physical conditions differ utterly from those which hold sway upon the earth. Surely these are not devoid of life? Nay, on such mighty globes life exists on a far grander scale of creation than anything that we can conceive of; life utterly different in form and motion to that which exists on our puny earth, and even composed, perhaps, out of entirely different elements to those which compose the living matter of world life.

Life is old, old as the universe itself. It has always existed generally throughout the universe in some form or other, and always will exist, no matter what happens to our little earth. The protoplasm of the earth is but the product of evolution of untold æons of ages, coming down to us in an unbroken line from ages when the world was a vast liquid globe of white hot material.

* Gautier, *Chem. News*, March 23rd, 1900.

**Chemical News*, Oct. 14th, 1904. See also the author's work "*Researches on the Affinities of the Elements*," p.p. 206-225.

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All the elements have circulated in succession through its structure, and then passed out again. First at the highest temperatures came the heaviest and least volatile elements, then as the temperature fell they gradually were eliminated and their places were filled by analogous lighter and more volatile elements, until at last living matter assumed its present composition. But this replacement of denser by lighter elements is now almost complete, for the principal elements already present in living matter are carbon, nitrogen, oxygen, and hydrogen. And these it will be noticed are among the very lightest non-metallic elements which, so far as we know, exist. No lighter elements, then, can replace those already present in the organism, and, therefore, there can be no further *very great* alterations in the temperature of living matter in the coming ages; but the world is still cooling. Consequently, age by age, century by century, the contrast between the temperature of living matter and the temperature of the surrounding medium is becoming more and more accentuated, and the difficulty of maintaining life is steadily increasing. I think, therefore, that so far as the surface of this earth is concerned, organic life is entering into its last stage of evolution.

UNIVERSITY OF KIEL, *May*, 1905.

A Raised Beach in Anglesey.

By G. H. BRYAN, F.R.S.

IN the island of Anglesey, about three miles north-east of Beaumaris and about one mile from Penmon, I came across an interesting example of a raised beach, of

Fig. 1.—Section of Boulder Clay near Penmon, Anglesey, with raised beach of sand overlying it.

which the accompanying photographs may give some idea. It is situated in a small bay, and rests on the top of a deposit of boulder clay at a height of some six feet above the existing beach. At the eastern extremity a stratum of broken shells occurs in the sand in several places, and is well shown in the second of the two photographs. In this shell deposit foraminifera are frequent; these are of large size and are mostly similar to the recent forms occurring on the sands below. They are all common species, apparently. Many of the specimens are, however, more or less worn and discoloured by iron oxide. The boulder clay itself is of a dark purple colour.

The existence of these raised beaches is interesting as showing the changes which have taken place in the level of the earth. The section shown in the first photo-

Fig. 2.—Section of the Raised Beach showing the white streaks of Shell Deposit.

graph has been exposed by the action of the sea, which at high tide reaches the foot of the boulder clay which it has exposed, and the identity of the foraminifera in the shell deposit with the recent ones in the sand below suggests that the changes of level have occurred in comparatively recent times.

CORRESPONDENCE.

The Action of Wood on Photographic Plates.

TO THE EDITORS OF "KNOWLEDGE."

DEAR SIRS,—I have read with much interest the article on the action of woods on photographic plates in the dark, which appears in this month's "KNOWLEDGE," and, believing the action due to the actual radio-activity of the wood, I was of opinion that an emanation should be visible under proper conditions, as is the case with the recognised radio-active substances—the intensity of the action of any radio-active substance appearing to depend on the *frequency* of the atomic disintegration rather than on the intensity of disintegration of each individual atom. By using a very sensitive screen, I have distinctly observed a bombardment from a piece of wood (I used white fretwood), each individual scintillation being about as bright as any I have observed from Uranium, Pitchblende, Polonium, or even Radium, the great difference being that, whereas from such substances the emanations pour forth in such numbers as to light up the screen with countless flashes, in the case of the wood they came singly or now and again in twos and threes, with a considerable interval between each. This would seem to account for the comparatively feeble and slow action of woods, as it would of necessity take considerable time before the cumulative effect would become evident.

I shall be very glad to know if scintillations from wood have been observed before.

Yours very truly,

CHARLES W. RAFFETY.

Strathmore, Streatham Common, S.W.
June 8th, 1905.

Electrotyping.

By DR. F. MOLLWO PERKIN.

IN the article on electrotyping in the January number of "KNOWLEDGE" various methods for reproducing medallions, coins, &c., were given. But this does not by any means exhaust the possibilities of electrolytic reproduction. Statuettes, and even large statues, can be, and often are, copied in a similar manner. Thus a statue of the Earl of Eglinton, which is 13½ feet high, was reproduced by Messrs. Elkington and Co., the weight of the electrolytic copper being about two tons. The reproduction of a statue, as may readily be imagined, is not by any means an easy or simple proceeding.

Generally speaking, the original is first formed in plaster of Paris. The plaster cast is then thoroughly saturated with boiled linseed oil or with melted paraffin wax. After standing for some time to allow the oil or wax to thoroughly set and harden, the entire surface is brushed over with graphite, and is then polished, so as to form a homogeneous conducting surface.

The model so prepared has conducting wires fixed against different portions of the surface, so that the electric current may be evenly distributed, and is then connected with the negative pole of the source of current and placed in a copper sulphate bath. When a coating of sufficient thickness has been obtained—about $\frac{1}{16}$ or more of an inch—the figure is removed from the bath and carefully washed. It is now necessary to remove the plaster form, and this is done by cutting the deposited copper in appropriate parts, so that the copper shell can be removed in portions. The fewer cuts that require to be made, the better, so that the portions of shell may be as large as possible.

The parts or "formes" of the copper shell so obtained represent the negatives or moulds upon which the positive is to be deposited. The inner portion of the formes are exposed to the fumes of sulphuretted hydrogen or are washed with a dilute solution of potassium sulphide. By this means the copper becomes coated with a thin film of copper sulphide, which is conducting, but upon which the copper to be deposited will not adhere. The outer surfaces of the mould are varnished to render them non-conducting. The various portions of the shell are then placed in a coppering bath and the current passed. When the deposited copper reaches a thickness of about $\frac{1}{7}$ of an inch, they are removed from the bath and well washed. The freshly-deposited shell is now carefully stripped off from the outer shell and the different parts joined together.

Stereotyping.—The most important application of electrotyping is in the preparation of stereotypes. When a large number of copies of a book require to be run off, and in order not to keep too large a quantity of type set up, a copy is reproduced in stereotype. The following description of the procedure adopted is the principle of the process, although individual firms adopt methods which vary in detail. Suppose it is required to produce a stereotype of a page of a book. The set-up type is placed face downwards upon a wax plate (gutta compositions are very often employed) cast upon a sheet of lead. It is then placed under an hydraulic press, by which means a perfect impression of the type is obtained in the wax. The type is then removed from the wax impression, which is then graphited, being generally first slightly warmed to render it just soft, so that it takes the graphite more thoroughly. Of course, it must not be sufficiently heated to blur the sharp edge of the impression. Pieces of stout brass wire are now pushed through the wax until they come in contact with the graphite at various parts where they will not injure the impression of the type. These pieces of wire are to make electrical contact so that when the current is passed it may be evenly distributed.

The prepared impression is now placed in the coppering bath and subjected to a fairly low current until the whole of it has obtained a complete coating of copper. It is now either left in this bath until a sufficiently thick shell has been produced or else it is taken out and placed in the quick-depositing bath, where a much higher current density is employed and the electrolyte is kept well agitated by blowing air through it. In the quick bath the shell may be finished in an hour or two, but may take a day or two in the slower bath (sometimes it is placed directly in the quick bath without being first treated in the slower one). As soon as a sufficiently thick deposit of copper has been obtained, it is removed from the bath, and if the stereo is small the wax is stripped away by hand. But in cases where the shell is of any considerable size, and, therefore, liable to be damaged, the wax is usually melted out with hot water or by blowing on steam. The galvano is now thoroughly cleansed from adhering wax and graphite by brushing it in hot water and with caustic soda or dilute hydrochloric acid. The next process is to back up the copper, because as the shell is less than one millimetre thick it is much too thin and fragile to use for printing purposes. But before the backing up metal, which usually consists of lead containing about 6 per cent. of antimony to harden it, is poured in, the shell must be tinned, otherwise the lead will not adhere. A very satisfactory way to do this is to first brush the inside of the shell with some soldering fluid, then place the shell face downwards upon a flat iron plate and float the iron plate upon a bath of molten metal slightly hotter than the melting point of tin. As soon as the copper shell has become properly heated, powdered tin is sifted over it, care being taken to give it a perfectly homogeneous coat. The tin melts and alloys with the copper, and now the lead can be poured in and it in turn alloys with the tin. After cooling and machining the edges and planing off the excess of lead, the stereo is ready for use.

Facing stereotypes.—When the copper stereo has been used for some time, owing to the copper being a soft metal, there is a tendency for the sharpness of the impression to become blurred; furthermore, certain printing inks, such, *e.g.*, as red ink, which contains vermillion—sulphide of mercury—act upon the copper and unite with it. In order to get over these difficulties the stereotypes are very often "steel" or nickel faced. The term steel facing is not quite correct, but it has been the custom to call iron when electrolytically deposited steel, because, although its hardness is not due to its carbon contents, yet it has very much the properties of steel. It is more usual to employ iron as a facing rather than nickel, because when used for a considerable time even iron and nickel facings wear off. It is then necessary to reface, but before this can be done it is essential that all of the original facing should be removed. The iron facing is very readily removed with dilute sulphuric acid, which has practically no action on the copper, but nickel is extremely difficult to

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dissolve, and the copper is very likely to be damaged at the same time. In order to steel face an electrotype, the surface is thoroughly cleansed from all traces of grease and made the cathode in an iron bath; a typical solution is one consisting of 100 grm. of ammonium chloride and 125 grm. iron sulphate, or 150 grm. iron ammonium sulphate in one litre of water. Generally a high current density is employed for one or two minutes, after which a current of 0.4 ampere to the square decimetre is employed for about five or 10 minutes, when the stereo is removed and carefully washed and dried. Nickel facing is done in the same manner, a nickel bath being employed in place of the iron bath, and the stereo left in for from seven to 10 minutes.

Reproduction of Gramophone Records.—As an illustration of the extreme accuracy of the impressions obtained by electrolytic means, the reproduction of gramophone records might be mentioned. As is well-known, the original gramophone record is made on a wax or composition cylinder, the mechanism of the instrument causing impressions of various degrees of fineness to be made upon the cylinder, the thickness depending upon the tone and pitch of the sound to be reproduced. Now, of course, the least fault or unevenness in the reproduction would completely ruin the record. In reproducing a record in copper the wax cylinder is carefully graphited and then, after being connected by means of conducting wires with the negative pole of the source of current, placed in a rapid depositing bath, where it is left for from 70 to 80 hours, a current of from three to four amperes per square decimetre being employed. By this means a good thick negative is obtained which can be used for producing duplicate copies of the original voice.

Dentistry.—Electrotyping is also employed in dentistry for producing mouth plates, &c. A model of the part of the mouth for which a plate is required is taken in wax and a plaster cast obtained from the wax model. The plaster cast is then prepared as already described, and placed in a silver bath, a silver electrotype being prepared; when the silver deposit is sufficiently heavy the model is placed in a gold bath and a heavy coating of gold deposited upon it. Drs. Pfanhauser and Hillischer have also experimented successfully with pure nickel in place of silver or gold.

Deposition upon Flowers, &c.—I will conclude this article by describing an interesting and artistic method for coating plants, leaves, or even insects with metallic deposits. A flower or leaf will not, under ordinary circumstances, conduct the electric current, therefore it is not possible to coat it with metal. It is, however, possible to render the surface conducting by chemical means in such a manner that the structure of the leaf is not spoilt. If a leaf is dipped into an ammoniacal solution of a silver salt and then exposed to the fumes of phosphorus, the phosphorus reduces the silver salt, and the whole surface becomes coated with a very thin film of metallic silver. The surface of the leaf is now conducting, and if a wire is fastened to the stalk and the leaf placed in a copper-plating bath, a coating of copper of any desired thickness can be deposited upon the leaf. A better method is to dip the leaf or flower into an alcoholic solution of silver nitrate and to then, after draining off the excess of the solution, expose to the action of sulphuretted hydrogen gas. By this means a thin and homogeneous film of silver sulphide—which will conduct the electric current—is obtained. The leaf is now placed in the depositing bath and coated with copper or silver as the case may be. If the operation is carefully carried out with a very low current and only a thin coating of metal deposited, all the veins and markings of the leaf remain. Leaves, flowers, and even insects, such as beetles or flies, when coated in this way can be kept for years without withering or decomposing. Of course, the actual leaf or insect is not seen, but is covered with a metallic shell which almost exactly represents the original.

Star Map.—No. 3.

Cetus, Eridanus.

THE constellations here shown are of no special interest. It may be noticed that there are two boundary lines dividing Fornax from Eridanus. The enclosed portion is included in the latter constellation by Proctor and some others, but, according to most authorities (including Gould) belongs to Fornax, and is lettered accordingly. The star at the top of the map marked μ is included by Proctor (and B.A.C.) in Aries, but other authorities call it μ Ceti.

α *Piscium* (I. h. 56 m. + 2° 14′), a double star of magnitudes 3 and 4. Distant 3½″.

o *Ceti (Mira)* (II. h. 14 m. − 3° 25′) a remarkable variable, usually varying from about 3rd magnitude to 9th. Though it has long been known, having been one of the first variables noted, it is still an enigma. Its period seems to vary greatly, but is usually about 331 days. In 1779 it was estimated as 1st magnitude; in 1868 it never attained more than 5th magnitude. During the last twelve periods the magnitude at maximum has varied from 2·5 to 4·7. The spectrum shows no signs of the star being double, and the variability is probably due to its own disturbances rather than to any outside cause.

γ *Ceti* (II. h. 38 m. + 2° 46′), a double star, distant 3½″. One of 3rd magnitude, yellow; other of 6th magnitude, blue.

θ *Eridani* (II. h. 54 m. − 40° 45′), a double star, distant 8·2″. Magnitudes 3½ and 5½. This star is supposed to have dwindled considerably in magnitude, having been classed as 1st magnitude in the time of Ptolemy, though now considered as 3·06.

With our special number for the British Association meeting will be issued Map No. 12 (South Polar Regions), which should prove of use to those visiting South Africa. With the August number, Map No. 6 (Leo and Cancer) will appear, which will show the region around the sun at the time of the coming eclipse.

The Word "Patent."

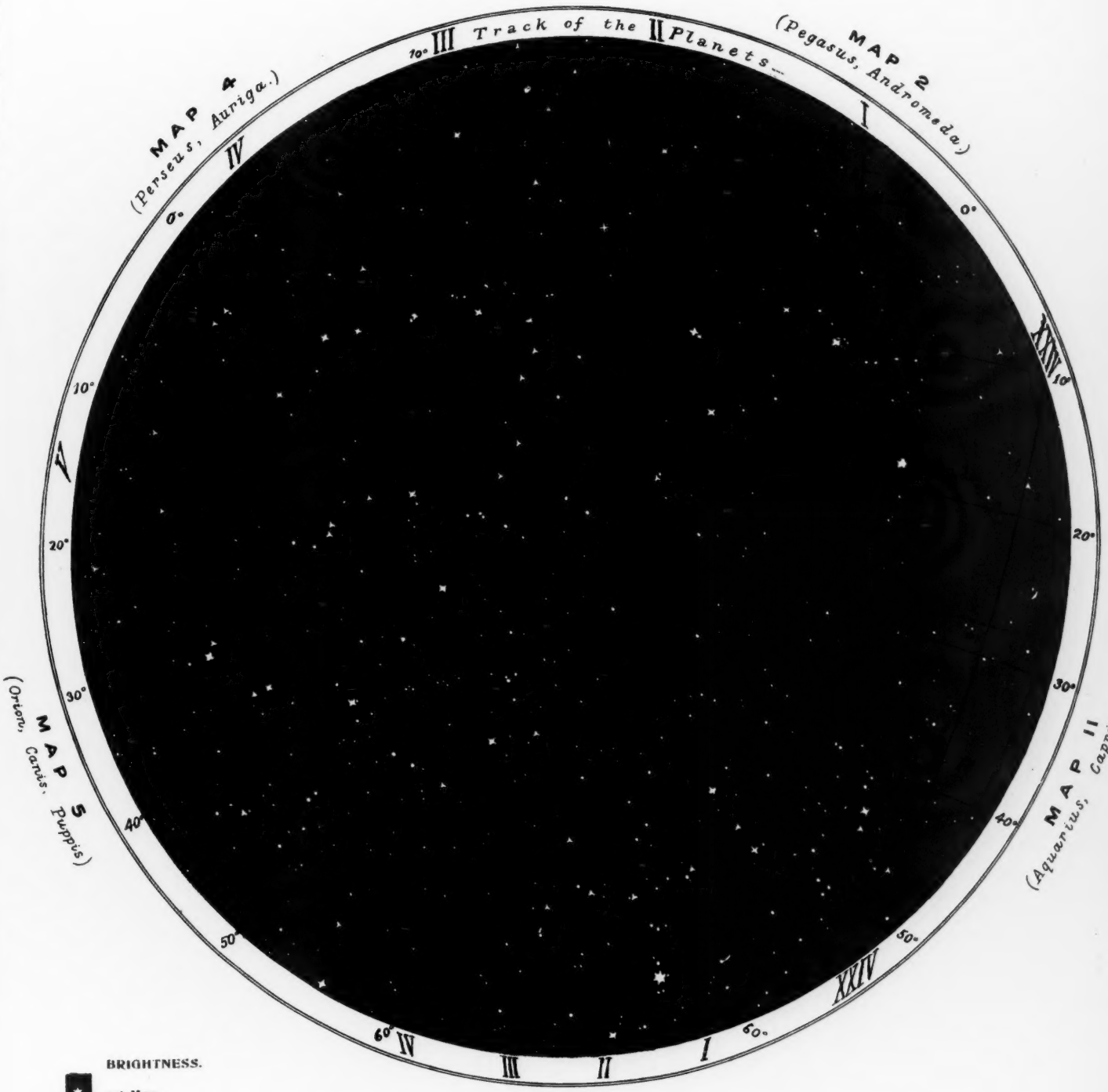
TO THE EDITORS OF "KNOWLEDGE."

SIRS,—The word "Patent" is one of those curiosities of the English language which tend to make it so puzzling to foreigners, and even to ourselves. Now this word is perhaps most generally pronounced *Paytent*, but in the profession it is more usually referred to as *Pattent*. There is one reason which I should like to point out in favour of using the former, and that is the confusion that is sometimes caused in mistaking the latter pronunciation for the word "Pattern." Jones may say, "That machine is my pattern," and Brown may later say, "That machine is Jones's patent, I heard him say so himself." When shall we take to teaching phonetics?

Yours faithfully,

R.

MAP No. 3.



MAP No. 3.

Cetus, Eridanus.

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The Migration of Flat-Fish.

By J. TRAVIS JENKINS, D.Sc., PH.D.

AT the present time when so much is heard of over-fishing and the consequent depletion of the fishing grounds, the question of the movements of sea-fish is one of considerable practical importance.

The majority of scientific experts agree that round fish, *i.e.*, fish of the herring and cod type, perform migratory movements of considerable magnitude, but as regards flat fish, *i.e.*, plaice, soles, and flounders, the consensus of opinion is by no means so unanimous.

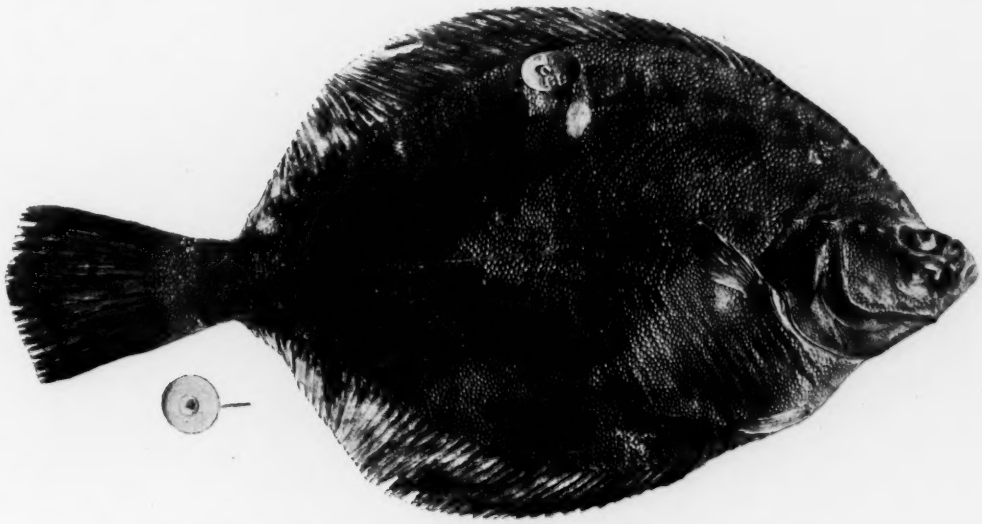
The International Committee for Investigation of the Seas, which has quite recently been established, has taken up, among other problems, the question of the migration of members of the flat fish family or Pleuronectidæ.

This international committee consists of scientific experts nominated by the Governments of England, Norway, Sweden, Germany, and Holland, and is subsidised by grants from the respective Governments.

Batches of marked Pleuronectids, chiefly plaice, have been marked from time to time and then liberated at various points in the North Sea. The mark used consists of a silver wire, which is threaded through the body of the fish in the position indicated in the diagram. To this wire are attached on the under side a bone button (shown to the left beneath the tail of the fish), and on the upper side a numbered brass label, in the present instance L. 169. Each fish is carefully measured and labelled, the whole operation from the time the fish is removed from the tank to the time it is replaced taking less than one minute.

It is hoped that by these experiments the amount and nature of the migration of flat fish will be determined; and attempts will be made to show the influence of the environment on migration. The intensity of fishing in any given area can be determined by the proportion of fish recaptured to the total number of marked fish returned to the sea. Since each marked fish is carefully measured both when it is returned to the sea and when re-captured, the rate of growth can also be determined. Plaice seem to withstand the marking operation wonderfully well, but soles are far more difficult to deal with successfully. No doubt other results will be arrived at, notably the efficacy of closed grounds in maintaining a reserve of fish and the effect of the density of fish population on the rate of growth.

The interest and co-operation of the fishermen is secured by means of a system of rewards payable for marked fish, the amount depending on the amount of information as to the locality of re-capture. It is surprising to find how many hands a marked fish will occasionally pass through before the label is detected. In one instance a label which was returned showed unmistakable signs of having been in the frying-pan.



Marked Plaice which travelled 40 miles in 20 days and was then recaptured.

It is yet somewhat premature to discuss the results in detail, but it may be said that the idea of plaice and soles being sedentary fish is now exploded. Plaice have been returned which have travelled 110, 130, and 210 miles respectively. As to rate of growth, an eight-inch plaice grows on the average from two-and-a-half to three inches per annum. More detailed reports will shortly be issued and are awaited by practical fishermen and biologists with equal interest.

Scientific Agriculture.

WE have received from the Committee of the Lawes Agricultural Trust a copy of the Directors' report on the work done at the Rothamsted Experimental Station for the year ending March 31st, 1905. The well-known experimental fields are still continued without any essential change; in addition a new field has been laid out to test the residual value of various manures in the

second and succeeding years after their application. Other experiments deal with calcium cyanamide, the new manure containing nitrogen derived from the atmosphere, and with the various cultivations of bacteria which have been recently introduced for the innoculation of leguminous crops, with the view of making them more efficient collectors of atmospheric nitrogen.

During the year in question seven papers have been issued from the Station in the "Transactions of the Chemical Society," the "Journal of Agricultural Science," &c., all of which deal with investigations on the soil, methods of soil analysis, &c. The annual losses of carbonate of lime in the Rothamsted soil has been determined, both that due to natural agencies and that caused by the use of manures. Certain restorative actions have been investigated which account for the maintenance of the fertility of many soils which are almost devoid of lime. Another of the papers deals with the remarkable accumulations of fertility in certain plots of land which have been allowed to run wild for the last twenty years, and have in that time gained nitrogen to an extent not readily explicable by the accepted theories.

A considerable list of investigations in progress is indicated, in which respect the Station receives considerable help from several voluntary workers, *e.g.*, two Carnegie Research scholars from the University of Edinburgh, and other post graduate students from Oxford and Cambridge are accommodated and provided with material for investigation, so that the Station, with its unrivalled opportunities for research, is becoming a training ground for experts in agricultural science.

The Lawes Trust Committee continue to find their income very inadequate to the proper development of the Station, only donations and subscriptions from various sources, including £300 from the Goldsmiths' Company, £50 from the Clothworkers' Company, £50 from Lord Rothschild, &c., have prevented a serious deficit on the year's working. Mr. J. F. Mason has also promised to erect and equip a new laboratory for agricultural bacteriology, which will be the first of its kind in this country, as a continuance of the experiments carried on for many years by his father, the late Mr. James Mason, at Eynsham Hall, Oxon.

Radiation Pressure.

PROF. J. H. POYNTING, F.R.S., the newly-elected President of the Physical Society, delivered an interesting address before that Society on "Radiation Pressure," of which the following is an abstract:—

"A hundred years ago, when the corpuscular theory held almost universal sway, it would have been easier to explain the pressure of light than it is to-day, when it is certain that light is a form of wave-motion. The means at the disposal of early experimenters were inadequate to detect so small a quantity; but if the eighteenth century philosophers had been able to carry out the experiments of Lebedew and of Nichols and Hull, and had they further known of the emission of corpuscles revealed to us by the kathode stream and by radio-active bodies, there can be little doubt that Young and Fresnel would have had much greater difficulty in dethroning the corpuscular theory and setting up the wave theory in its place. The existence of pressure due to waves, though held by Euler, seems to have dropped out of sight until Maxwell, in 1872, predicted its existence as a consequence of his electromagnetic theory of light. The first suggestion that it is a general property of waves is probably due to Mr. S. T. Preston, who, in 1876, pointed out the analogy of the energy-carrying power of a beam of light with the mechanical carriage by belting, and calculated the pressure exerted on the surface of the sun by the issuing radiation. It seems possible that in all cases of energy transfer, momentum, in the direction of transfer, is also passed on, and that there is, therefore, a back pressure on the source. Though there is as yet no general and direct dynamical theorem accounting for radiation pressure, Prof. Larmor has given a simple indirect mode of proving the existence of the pressure which applies to all waves in which the average energy density for a given amplitude is inversely as the square of the wave-length. He has shown that when a train of waves is incident normally on a perfectly reflecting surface, the pressure on the surface is equal to $E(1+2u/U)$, where $E/2$ is the energy density just outside the reflector in the incident train, U is the wave-velocity, and u the velocity of the reflector, supposed small in comparison with U. In a similar manner it can be shown that there is a pressure on the source, increased when the source is moving forward, decreased when it is receding. It is essential, however, that we should be able to move the reflecting surface without disturbing the medium except by reflecting the waves. Though Larmor's proof is quite convincing, it is interesting to realise the way in which the pressure is produced in the different types of wave-motion. In the case of electro-magnetic waves, Maxwell's original mode of treatment is the simplest. A train of waves is regarded as a system of electric and magnetic tubes transverse to the direction of propagation, each kind pressing out sideways; that is, in the direction of propagation. They press against the source from which they issue, against each other as they travel, and against any surface on which they fall. In sound-waves there is a node at the reflecting surface. If the variation of pressure from the undisturbed value were exactly proportional to the displacement of a parallel layer near the surface, and if the displacement were exactly harmonic, then the average pressure would be equal to the normal undisturbed value. But consider a layer of air quite close to the surface. If it moves up a distance, y, towards the surface, the pressure is increased. If it moves an equal distance, y, away from the surface, the pressure is decreased, but to a slightly smaller extent. The excess of pressure during the compression half is greater than its defect during the extension half, and the net result is an average excess of pressure on the reflecting surface. Lord Rayleigh, using Boyle's Law, has shown that this average excess should be equal to the average density of the energy just outside the reflecting surface. In the case of transverse waves in an elastic solid, it can be shown that there is a small pressure perpendicular to the planes of shear, that is, in the direction of propagation, and that this small pressure is just equal to the energy density of the waves. The experimental verification of the pressure of elastic solid waves has not yet been accomplished, but the pressure due to sound-waves has been demonstrated by Altberg, working in Lebedew's laboratory at Moscow, the pressure obtained sometimes rising to as much as 0.24 dynes per sq. cm. By means of a telephone manometer it was found that through a large range the pressure exerted on a surface was proportional to the intensity of the sound.

"Both theory and experiment justify the conclusion

that when a source is pouring out waves, it is pouring out with them forward momentum which is manifested in the back pressure against the source and in the forward pressure when the waves reach an opposing surface, and which, in the meanwhile, must be regarded as travelling with the train. It was shown that this idea of momentum in a wave-train enables us to see the nature of the action of a beam of light on a surface where it is reflected, absorbed, or refracted without any further appeal to the theory of the wave-motion of which we suppose the light to consist. In the case of total reflection there is a normal force upon the surface, in the case of total absorption there is a force normal to the surface and a tangential force parallel to the surface; while in the case of total refraction there is a normal force which may be regarded as a pull upon the surface or a pressure from within. In any real refraction there will be reflection as well, but with unpolarized light, in the case of glass, a calculation shows that the refraction-pull is always greater than the reflection-push, even at grazing incidence. An experiment, made by the President in conjunction with Dr. Barlow, was described to serve as an illustration of the idea of a beam of light being regarded as a stream of momentum. A rectangular block of glass was suspended by a quartz fibre so that the long axis of the block was horizontal. It was hung in an exhausted case with glass windows, and a horizontal beam of light was directed on to one end of the block so that it entered centrally and emerged centrally from the other end after two internal reflections. Thus a stream of momentum was shifted parallel to itself, or in this particular case a counter-clockwise couple acted on the beam. By suitable means the clockwise couple on the block, due to the pressures at the two internal reflections, was distinctly observed and approximately measured. The result obtained was of the same order as that deduced from the measurement of the energy of the beam by means of a blackened silver disc.

"The extreme minuteness of these light forces appears to put them beyond consideration in terrestrial affairs, but in the solar system, where they have freer play, and vast times to work in, their effects may mount up into importance. On the larger bodies the force of the light of the sun is small compared with the gravitational attraction, but as the ratio of the radiation pressure to the gravitation pull varies inversely as the radius if the density is constant, the pressure will balance the pull on a spherical absorbing particle of the density of the earth if its diameter is about a hundred thousandth of an inch. The possible effects of radiation-pressure may be illustrated without going to such fineness as this. In the case of a particle of the density of the earth, and a thousandth of an inch in diameter, going round the sun at the earth's distance, there are two effects due to the sun's radiation. In the first place, the radiation-push is $\frac{1}{00}$ of the gravitation-pull, and the result is equivalent to a diminution in the sun's mass. In the second place, the radiation absorbed by the particle, and given out again on all sides, is crushed up in front as the particle moves forward and is opened out behind. There is thus a slightly greater pressure on the advancing hemisphere than on the receding one, and this appears as a small resisting force in the direction of motion. Through this the particle tends to move in a decreasing orbit, spiralling in towards the sun. As there is good reason to believe that some comets, at least, are composed of clouds of dust, there is hope that some of their eccentricities may be explained by the existence of radiation pressure. If the particles of a dust cloud circling round the sun are of different sizes or densities, the radiation accelerations on them will differ. The larger particles will be less affected than the smaller, will travel faster round a given orbit, and will draw more slowly in towards the sun. Thus a comet of particles of mixed sizes will gradually be degraded into a diffused trail lengthening and broadening, the finer dust on the inner and the coarser on the outer edge. If a planet, while still radiating much energy on its own account captures and attaches to itself, as a satellite, a cometary cloud of dust in which there are several different grades, with gaps in the scale of size, it may be possible that in course of time the radiation pressure effects will form the different grades into different rings surrounding the planet. Such may possibly be the origin of the rings of Saturn."

REVIEWS OF BOOKS.

Geology: Processes and Their Results. By T. C. Chamberlin and R. D. Salisbury (Murray). Pp. XIX. and 654, plates 24; 21s. net.—This excellently printed and fully illustrated work will meet with a hearty welcome from English geologists. Its treatment of the subject is original, and proceeds from the point of view that the science is a unit, that its one theme is the history of the earth, and that the discussions of dynamic geology, physiographic geology, &c., apart from their historical bearings, lose much of their significance and interest. The present condition of scientific knowledge is set forth in such a way that the student will be introduced to the methods and spirit of the science, and a sympathetic interest excited in its historical progress.

In a chapter devoted to the work of running water, examples are freely drawn from North American rivers, in which are seen every condition of existence, old, middle-aged, and juvenile. In our country, we have few instances which show, for instance, such as does the Mississippi, the ox-bow lakes, evidence of the former existence of meanders which have since been abandoned. Most of our rivers are in a condition of early old-age, and only by some sudden tilt of either east or west coast, or an uprising of the central axes of our country, would rejuvenation of our rivers take place, and the cycle commence over again.

It is pleasing to see the authors utilising the miniature deltas, which occur anywhere on a muddy coast, or even in a street in rainy weather, where a drain has been choked up, to illustrate the formation of the great deltas of the world. I remember being greatly struck by the deltas which are formed at the base of the muddy parts of the Lower Greensand Cliffs, near Luccombe Chine, in the Isle of Wight. Homely object lessons can be obtained of immense value from such examples close at hand.

In the chapter on Structural Features of Igneous Rocks, the authors discuss the origin of hexagonal columnar structure. In nature, generally speaking, the hexagon is the result of the pressure exerted by the walls of circles upon one another. In the cooling of homogeneous lava, it is postulated that it contracts about equally in all directions. If the contractile force be regarded as centring about a number of equidistant points, then at any one point the least number of cracks which will relieve the tension in all directions is three, and these cracks, if radiating symmetrically, would enclose angles of 120°, the angle of the hexagonal prism. The theory is interesting, but scarcely explains the breaking-up of the columns into parallel laminæ, nor why the supposititious points about which the contractile force centres should be, almost invariably, immediately beneath one another. If they were not, the columnar structure would be lost.

We are so accustomed to talk about the extinct volcanoes in the moon that we perhaps sometimes overlook the theory that holds weight in some quarters, that what appear to be craters may be indentations produced by infalling meteorites or planetoids. The reproduction of a portion of a photo-

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graph of the moon's surface in the volume before us certainly suggests, as a cause of the shallow craters, the falling-in of bodies, as much as the belching-out of lava or bombs. The reproduction in another part of the book of fossil rain-markings bears a remarkable resemblance, on a small scale, to what have been long regarded as lunar craters, except that the small central cones are nearly always absent in the former. This may, however, be due merely to the great fluidity of water, and because the rain-drops were quickly absorbed in the sedimentary deposit forming, and since the falling body was more fluid than the receiving body. Let the falling body be the more solid of the two, then the more fluid will give rise to a central cone, on the disappearance within of the falling body, and the permanence or otherwise of the cone will depend on the degree to which the receiving body has approached solidity. The subject is fascinating. The moon may have been the recipient of a bombardment, rather than the bombarding element itself.

In the 76 pages devoted to the work of snow and ice we have this most difficult subject dealt with in an admirable manner. The illustrations are superb, and show, in many cases very clearly, the remarkable stratified formation of exposed sections of glaciers. Æolian denudation receives due recognition in the chapter dealing with the atmosphere as a geological agent, and the migration of dunes are admirably illustrated. There is nothing but praise to be said for the work, and we hope that it may make its way into every important library, and into the hands of many who may feel repelled by the strange. E. A. M.

Electro-Chemistry.—Practical Methods of Electro-Chemistry, by F. Mollwo Perkin (Longmans, Green and Co.); price 6s. net. —Sir William Ramsay has recently spoken of the enormous revolution in our chemical industries, only as yet dimly perceived, which awaits the application of electro-chemistry to their development; and since what is to-day done in the laboratory will to-morrow have to be done in the manufactory, the greatest importance attaches to the establishment of a sound method in the teaching of electro-chemistry to students. That end is brought perceptibly nearer by Dr. F. Mollwo Perkin's sound laboratory guide to these electro-chemical methods, which in recent years have undergone such rapid development and have attained such extreme importance. The volume is above all things practical; it is what it professes to be, a real guide and instructor to the student. The ground having been cleared by definitions of electrical magnitudes and units, and by descriptions of measuring instruments and electrolytic apparatus, the instruction proceeds by graduated steps to the actual methods of electro-chemical analysis. The conditions of the quantitative electro deposition of the metals; a section on quantitative oxidation and reduction of the electrodes; the separation of metals from mixed solutions of their salts; and finally preparative electro-chemistry—both of inorganic and of organic compounds—are the chief divisions of the book and of its instructional chapters. It is supplemented by a table of five-figure logarithms, with instructions for their use; and it bears from title to imprint the evidence of the carefully considered work of a scientist who is as well able to impart knowledge as to accumulate and digest it.

The Rational Almanac (M. B. Cotsworth, Holgate, York; price 5s. net). This is an odd-shaped book of over 470 pages, crammed full of writing, diagrams, and illustrations, and it takes some little time to find out exactly what it is all about. One naturally turns to the "Summation" at the end, where one might expect to find some simple and succinct explanation, but this alone extends over 100 pages, and seems to be a history of the world from early times. A large part of the book is devoted to explanations of the probable astronomical purposes of the Pyramids and many druidical and other erections, and their practical use in connection with the calendar. But we need not refer further to them, interesting though they be. The real object of the book is to suggest a reform in our calendar, and one in favour of which much can be urged. It is to divide the year into 13 months of 28 days each. This would be very convenient, as the days of the week would run concurrently with the days of the month. It is suggested, to complete the year, that Christmas Day should be extra, and not count either as a week-day or day of the month. The author lays stress on what we should consider another matter, that is "the inconvenience which results from drifting Easters," &c. These moveable feasts can be, and we think ought to be, done away with (for business purposes) without otherwise altering our present well-established calendar.

Studies in General Physiology, by Jacques Loeb. (Chicago. London: Fisher Unwin; price £1 11s. 6d. net; 782 pp.)—These two volumes will be welcomed by all students of Comparative Physiology, who have hitherto been obliged to seek for Professor Loeb's papers in the various American and German periodicals in which they have appeared. "Control of the Phenomena of Life" is the dominant note of his work, which deals with the mechanical determination of (*a*) animal motion (heliotropism, geotropism, &c.); (*b*) animal organs (regeneration, heteromorphosis, &c.); (*c*) life itself (fertilisation, artificial production of normal embryos from unfertilised ova, &c.) The arrangement of the book is a little tiresome, the papers being reproduced in order of publication, not grouped together by subject. On the other hand, the vital interest of Loeb's work consists in the development of one point out of another, and we can follow his train of thought from first to last in these studies. The general reader would do well to turn in the first instance to p. 497 of Part II., where he will find an admirable 10-minutes' lecture on "The Physiological Problems of To-day" (delivered 1897). In this the importance of comparative physiology, which "alone enables us to discriminate between the general properties of living matter and the functions of specific organs, such as the blood, the nerves, the sense-organs, chlorophyll, &c.," is insisted on. Professor Loeb pleads for the extension of that field of comparative physiology which he terms physical morphology, or "the connection between the chemical changes and the process of organisation in living matter," and to this fascinating subject many of his studies are devoted. Of late he has turned from the structural phenomena common to plants and animals to the constitution of living matter itself, as interpreted by physical chemistry (stereo-chemistry, or the geometrical configuration of the molecule, osmotic pressure, &c.); and the remainder of the book is devoted to the brilliant series of experiments upon the dissociation of electrolytes—physiological action of positive or negative ions, rate of their diffusion through the living tissues, and so on—by which Professor Loeb has, perhaps more than any other physiologist, established the fundamental importance of ionic dissociation in physiology and pharmacology.

Animals I Have Known.—In this companion volume to his "Birds I Have Known," (pp. 304, 40 illustrations; T. Fisher Unwin; price 5s.), Mr. A. H. Beavan states that it has been his object simply to record his experiences of animals (*i.e.*, mammals) in various lands, without reference to scientific theories as to their origin and distribution. Had he adhered strictly to this resolution all might have been well, and we should not have been informed that the Australian platypus is the only mammal that lays eggs, and that the South American vampire abrades the skin of its victims with its canine teeth. If an author will enter upon technicalities, he should take means to ascertain that they are correctly stated. A large portion of the book is devoted to the mammals (wild and domesticated) of our own country; but Mr. Beavan has had the good fortune to visit Australia and South America, and has much to tell us (which is for the most part well worth reading) concerning the very remarkable mammalian faunas of those two countries. Of especial interest are his observations with regard to the tail of the Tasmanian wolf, which, he says, is essentially part of the creature's body, and cannot therefore be "wagged." The numerous illustrations are for the most part excellent. If only the author had asked a scientific naturalist to revise the proof sheets, we should have had nothing but praise for his little volume.

The Inventor's Guide to Patent Law and the New Practice.—By James Roberts, M.A., LL.B., Barrister-at-law (John Murray), price 2s. 6d. net, 100 pp. The inventor who is about to take out a patent, whether already experienced in such matters, or a novice, will always be glad to consult a small book which gives clear instructions as to the *modus operandi* of obtaining the patent, and of the legal procedence, especially now that several important changes have been made. This book admirably fulfils the requirement, and, being by a barrister and author of a larger work on the same subject, may be looked

upon as reliable and unbiassed. We are frequently having foisted upon us guide books of "How to take out a Patent," which prove to be nothing more than the advertisement of some enterprising firm of patent agents, and such works, though frequently quite correct, one is bound to regard with a certain amount of suspicion.

Electro-magnetic Theory of Light, by C. E. Curry, Ph.D. Part I.; pp. vi. + 400. (London: Macmillan; 12s. net.)—This is one of those books of which we would speak nothing but good if we could. It has evidently been laboriously compiled, and the whole ground has been covered of that portion of the theory which was developed by Maxwell himself. More modern developments which must include such matters as dispersion, which was left unexplained by Maxwell in his Treatise [but which were *understood* by him as is shown by an examination question set by him—as pointed out by Lord Rayleigh], have been relegated to a second part. Each section is followed by a large number of examples, very many of which have been excellently chosen. Since these are often worked out in detail they form an excellent means for a student to familiarise himself with the subject. When we have said this, however, any praise of a fairly enthusiastic kind is at an end. The style in which the book is written is not good; indeed it is repellent. We have pored over many paragraphs without being able to obtain their meaning. Special points which seem to be peculiar to the author displease us most of all. We do not like his use of the phrases primary and secondary waves in a sense distinct from that in which they are already used—viz., in connection with Hugyen's theorem. Still less do we approve of the whole page devoted to a fanciful analogy to primary and secondary currents by which an attempt is made to justify the new use to which he puts these phrases. Simple methods of proof of theories which are familiar to us are replaced by elaborate and confusedly stated methods without any gain in accuracy. On the whole we have said enough to indicate our opinion; and conclude by stating that the publishers have done their part in a most excellent manner.

The Norwegian North Polar Expedition, 1893-6. Edited by Fridtjof Nansen. Vol. VI. (Longmans, Green and Co.; price 36s. net.) This great volume deals with the meteorological results of the expedition, and is the work of Professor H. Mohn, who planned the meteorological work to be conducted, and superintended the equipment sent with the *Fram*. Such a great work, conducted with skill and care, forms an important addition to scientific literature. The observations, continued through three years of travel in regions hitherto unknown, were mostly conducted by Captain S. Scott Hansen, who had received special instruction in this subject from Professor Mohn. The book is mainly divided into three portions; the first describing the instruments and observations; the second, the actual diary tables of observations; and the third the results worked out. The observations were made every four hours, and show the direction and velocity of the wind, the barometric pressure, the temperature, the vapour-tension, relative humidity, and clouds. As regards the direction of the wind, which, by the way, has an important bearing on the probabilities regarding the fate of the Andrée expedition, a cursory glance would lead one to suppose that the various winds were fairly equally prevalent, some predominating at certain seasons. The value of this collection of observations is the more evident seeing that they extend over three years, for otherwise one might be led into supposing that certain winds predominated during certain months; but the records of other years seem, in most cases, to prohibit any such conclusion. In July, the month during which Andrée started in his balloon, the prevailing winds were—1894, W.N.W. and W.; 1895, W. and W.S.W.; 1896, S.W. and S.S.W. As regards the velocity of the wind, the monthly means vary from about three to five metres per second. The velocity, as may be expected, was on the average greater during cloudy weather than with a clear sky. The maximum velocity recorded was only 18 metres per second, and the occasions were very rare when this figure was approached, so that anything approaching a real storm was rare. The barometric pressures call for no comment, varying as a rule between 740 and 780 mm., but when we come to temperatures we find some unusual figures. The coldest month was apparently March, with a mean of $-37°$ C. the minimum recorded being $-52°$. In July and August we occasionally find a mean daily temperature just above freezing point. At the end of the book are a number of charts and diagrams.

Ambidexterity, or Two-Handedness and Two-Brainedness. By John Jackson (Kegan Paul). This is a large book to devote to so little-studied a subject, and we hope it may be the means of bringing forward the importance of that most useful accomplishment of being able to use both hands, or perhaps we should say either hand, for all ordinary purposes. To be able to write two letters simultaneously, or to draw two different pictures at the same time, is certainly an extraordinary feat of dexterity, but is now described as being easily learnt. One hand at a time is, however, sufficient for most people to employ, and it is certainly desirable to acquire the knack of using the left hand for writing and other purposes.

A Catalogue of Zodiacs and Planispheres, by the Rev. A. B. Grimaldi, M.A. (Gall and Inglis), is a most useful compilation describing the various records from the earliest times of zodiacs in all countries. The number of entries is 1,444. Some of them are a little vague, as, for instance, No. 148, which reads: "A Chinese zodiac is mentioned by Pettigrew," and but few of them have the date or supposed age of the record. Nevertheless, the list should prove of great value to all interested in this subject.

Petrol Motors Simply Explained. By T. H. Hawley (Percival Marshall; price, 1s. net). This is one of those useful little manuals intended to instil into the mind of the Man in the Street some knowledge of the working of the machine that carries him about. In the preface the author explains that "the object aimed at is rather a simple explanation of the principles governing the action of the petrol motor, and the manner in which the power so generated is utilized to propel the vehicle, together with a few hints on control mechanism and driving."

Notes and Questions in Physics. John S. Shearer, Ph.D. (Pp. vii. + 281. New York: The Macmillan Company; London: Macmillan and Co.; price 7s. 6d. net).—The object of this volume is to provide a collection of examples in physics with a sufficient number worked out to suggest methods in typical cases. The fact that students continually complain of their inability to solve simple problems in physics is a clear indication that the fundamental principles are not fully grasped; and it is essential therefore to supplement lecture and laboratory work by a reasonable amount of problem work. It is in this way only that a student learns whether he has really understood a principle. The greater number of the problems selected here can be worked by simple algebra or arithmetic; though in a few cases the calculus is necessary. It is obviously intended that the book should be used with the assistance of a teacher, since answers are not given; the private student is hereby put at a disadvantage, for he has no test as to the accuracy of his work. There is surely very little objection to including the answers in any book of collegiate standing, whatever method may be found best for a school book. If a student who has come to years of discretion thinks right to merely "crib" the answer he reaps his reward. Such a man will prove of little use in this world, at any rate. The problems are judiciously chosen, so that both the academic and the technical student is catered for. We notice a few mistakes. There are unfortunately some in the tables at the end. When are text-book writers going to realize that the fundamental standards of mass and length are no longer the old ones "kept in the Archives at Paris." Is the work of the International Bureau a small thing that it should be so ignored?

Elementary Microscopy. By F. Shillington Scales, F.R.M.S. (Baillière, Tindall, and Cox; price 3s.) A handbook for beginners, which is thoroughly practical, concise, and explanatory. With so many modern improvements of detail, most of the larger handbooks on the microscope are becoming out of date, and they are, moreover, as a rule, slightly beyond the requirements of the mere beginner, who wants to know in as few words as possible what sort of instrument to purchase and how to use it. "Nature, as revealed by the microscope, is quite outside the scope of this little book," which is very properly confined to descriptions of the instrument and its accessories, with hints on its manipulation, and methods of mounting objects for inspection. There are 78 good, clear

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illustrations, and a useful list of the principal books on the subject is added.

Natural History in Zoological Gardens.—By F. E. Beddard, F.R.S., &c. (London: Archibald Constable and Company, Limited; price, 6s. net). From his position as head of the coroner's (otherwise "prosector's") department at the establishment in the Regent's Park, the author of this well-illustrated little volume of something over three hundred pages has enjoyed unrivalled opportunities of acquiring information with regard to the manners and customs of animals in menageries; and when we first opened the covers we were in hopes of finding that such information had been made public, and that we should find out the average lengths of the lives of different species in captivity, and from what causes they generally perish. To our intense disappointment, we soon found that the work, although it undoubtedly gives a few data on these points, is of a totally different class, being, in fact, a kind of sketchy natural history of terrestrial and aërial vertebrates, as exemplified mainly by species to be met with in zoological gardens. From this point of view (and we have really no right to criticise it for what it is not) the book may be pronounced as fairly satisfactory, and as conveying a large amount of information, although, from the nature of the case, comparatively little is novel. Mr. Beddard treats his subject from the systematic point of view, and consequently takes the various "orders" and species in serial sequence, devoting the largest amount of space to mammals, and omitting fishes altogether, as being not generally represented to any important extent in menageries—unless, indeed, as food for seals. For the same reason whales are omitted from the purview; and it is on account of such omissions that we think the work would have been much better if the animals had not been described systematically. As a minor matter, we confess to being utterly puzzled by the titles selected for some of the chapters. For instance, we find the fourth headed the "Deerlet," and yet it contains notices of such animals as elephants, lions, tigers, &c.; while under the title of the "Polar Bear" we find included such animals as seals and rodents. Surely no chapter-headings at all would have been far preferable. Again, we must venture to take exception to some of the absurd "English" names manufactured for some of the animals described, such as (p. 285) the "adorned ceratophrys," which is a survival of the old bad principle of attempting a half-translation of the scientific names once adopted generally in the gardens. As regards illustrations, the book is for the most part all that can be desired; and, although it cannot be described as of enthralling interest, while, in our opinion, it would be all the better for the omission of many passages which we suppose are meant to be humorous, it undoubtedly contains a very large amount of zoological information.

A Student's Text-Book of Zoology, by Adam Sedgwick, F.R.S., &c. Vol. II. (London: Swan Sonnenschein and Co., Ltd.). —That any one individual should attempt at the present day to write single-handed a detailed scientific text-book dealing with the whole realm of zoology, and, what is much more, should be capable of doing so in a more or less masterly manner throughout, is little short of marvellous. Nevertheless, this is the gigantic task to which Mr. Sedgwick has committed himself, and the present volume and its predecessor afford convincing proof that he has over-estimated neither his scientific abilities nor his powers of long-continued and close work. Faults and imperfections must of necessity make their appearance in such a work, but the wonder in the present case is not that they are so many, but rather that they are, comparatively speaking, so few. Whether it is really advisable for a single writer to undertake a task of this colossal magnitude, and whether it is not preferable to follow the prevailing fashion of a "symposium" in the making of works of this nature, may be an open question. It is certain, however, that undivided authorship permits of the subject being treated in a much more uniform style than would otherwise be possible, and it ensures that all parts of it are viewed, so to speak, through the same glasses. In the present instance it may be confidently asserted that few, if any, biologists in this country at any rate would be capable of carrying out the task in the manner in which Mr. Sedgwick has so far acquitted himself. That an author can write throughout a work of this description from first-hand knowledge is, of course, a manifest impossibility; and in the present volume Mr. Sedgwick candidly acknowledges his indebtedness to several contemporary specialists. For his account of the bony fishes he has, for example, drawn almost exclusively from the recent work of Mr. Boulenger; and critical zoological readers who carefully scrutinize the definitions of the various groups will scarcely fail to detect that they have been drawn up by one who is not an expert on the subject, and that in certain instances they are not absolutely diagnostic.

While the first volume deals with molluscs and the lower invertebrates, the one before us is devoted to the chordata, as restricted by the author; that is to say, the lancelet (miscalled *Amphioxus*) and the vertebrates. In the third volume are to come the ascidians, acorn-worms, echinoderms, and arthropods; while in the fourth and final volume will be discussed the general principles of zoology.

Perhaps the most striking feature of this portion of Mr. Sedgwick's work is the vast amount of information he has managed to convey within the limits of one fair-sized octavo volume; it has, of course, been practicable to effect this only by condensing statements in the greatest possible degree; and this very concentration is of itself a sufficient proof of the enormous amount of labour that has been expended on the task. On the whole, the author is well up to date in his facts, this being especially noticeable in his treatment of the Proboscidea and their apparent relationship to the Sirenia. On the other hand (p. 539), in referring to the marsupial *Myrmecobins* as being allied to the Jurassic mammals, he appears to have overlooked the recent work of Mr. Bensley. In regard to the scheme of classification, we are compelled to differ from the author in many points, notably in regard to the separation of the bony fishes from their enamel-scaled forerunners, and in the refusal to accord to the egg-laying mammals a taxonomic rank higher than that assigned to the various "orders" of the placental group, which, by the way, are more numerous than is admitted by many authorities. Neither do we like to see the mammal-like anomodont reptiles placed between plesiosaurs and chelonians, instead of at one end of the class. To an already fairly long list of corrigenda, the following items may be added: The edentates of S. America do not date from the Lower Eocene or Cretaceous (p. 543). Lipoterna is given throughout in place of Litopterna. *Aglossidæ* (p. 309) is not the family name for the Surinam toad and its relatives. The present reviewer is wrongly credited with having written a book entitled "Deer and their Horns" (p. 588). The statement (p. 599) that whalebone sold for £150 per ton in the early part of the 15th century surely refers to the 18th century. "Style" cannot be expected in a work of this nature, but it is certainly unnecessary to make six consecutive sentences begin with the word "they," as on page 551. Although some of the illustrations are excellent, the less that is said about a large proportion the better.

Despite imperfections, many of which, from the nature of the case, could scarcely have been avoided, the volume is worthy of every commendation, if only as an example of hard and conscientious labour.

Our Stellar Universe: A Road-Book to the Stars, by T. E. Heath, the author of an article appearing in this issue of "KNOWLEDGE," has been received, and will be reviewed in our next number.

Smithsonian Miscellaneous Collections, vol. ii. part 3, has a varied assortment of interesting papers, including "Inquiry into the population of China," by W. W. Rockhill; Seeds of Aneimites," by David White; "The Sculpin and its habits," Theodore Gill; "The Construction of a Vowel Organ," E. W, Scripture; "Habits of a Social Spider," "Fossil Plants," and others.

Graphs for Beginners, by Walter Jamieson (Blackie and Son), 1s. 6d., and **Easy Graphs,** by H. S. Hull, M.A. (Macmillan), 1s., are two little works dealing with the same subject. The first-named treats of graphs from a general point of view, as a means of creating interest, cultivating habits of observation, and stimulating the reasoning powers, rather than as a branch of pure mathematics. The second book is very similar in its general scope, and is also intended for beginners.

Griffin's Catalogue of Scientific Apparatus, in three parts, 1 including Mechanics, Hydrostatics and Pneumatics; 2, Sound, Light and Heat; and 3, Electricity and Magnetism, is a very complete, descriptive list of apparatus useful and necessary to the physicist.

XUM

NOTES.

ASTRONOMICAL.

By CHARLES P. BUTLER, A.R.C.Sc. (Lond.), F.R.P.S.

Further Notes on Jupiter's Sixth and Seventh Satellites.

PROFESSOR PERRINE, the discoverer of these two new satellites, has recently published a short *résumé* of their features as at present determined. He makes the interesting suggestion that the large inclinations of the orbits of both satellites to the plane of the planet's equator may be an indication that these bodies have not always belonged to Jupiter, but that they may be captures.

Sixth Satellite.—Owing to its brightness this has been readily photographed in ten minutes with the Crossley reflector, and plates have been obtained on thirty-six nights, the last date of observation being March 22, as the planet is now too near the sun for the satellite to be examined.

A preliminary examination of the orbital elements shows the inclination to the ecliptic and the planet's equator to be about 30°. The period is probably about 250 days, with a mean distance from the primary of about 7,000,000 miles; but it is not yet possible to say with certainty what is the direction of the orbital motion. The actual diameter cannot be measured, but the determinations of brightness indicate a diameter of 100 miles or less.

Seventh Satellite.—A minute examination of negatives of the sixth satellite, taken with the Crossley reflector in 1905, January 2, 3, 4, showed the presence of a much fainter object, which apparently belongs to Jupiter. It was at that time to the N.W. of Jupiter, and had a motion towards the planet.

The many difficulties which presented themselves in determining the true character of the sixth were still greater in the case of this newer one. Being so much fainter, the observations were more difficult to secure, owing to the long exposures required, and its motion was likewise harder to interpret. It was considered, however, that the determinations of February 21 and 22 made it clear that it belonged to Jupiter. The seventh satellite is not shown on the negatives taken during December, 1904, as it was just outside the field then under observation. Definite measures have been secured on the results of 20 nights, the last of which was March 9.

A preliminary investigation shows the orbit to be quite eccentric, the mean distance from Jupiter being about 6,000,000 miles, with a period of about 200 days.

The orbit is inclined to the plane of Jupiter's equator at an angle of about 30°, but the direction of motion is at present uncertain. Its photographic magnitude is estimated to be not greater than the 16th. From this fact and a comparison with the other satellites and the asteroids it is probable that the seventh satellite has a diameter of about 35 miles.

A Probable New Star, R.S. Ophiuchi.

In a special communication from the Harvard College Observatory Professor E. C. Pickering draws attention to further observations of this so-called variable star, which shows certain peculiarities similar to those seen in novæ.

New stars can be distinguished from variables, in many cases, only by their spectra. The usual life of a new star is marked by its sudden appearance where no star is previously known to have existed, and a gradual fading away during which it changes into a gaseous nebula. T Coronæ, Nova Persei, P Cygni, and η Carinæ are instances of varied development.

It is found that on July 15, 1898, the spectrum of the star R.S. Ophiuchi was of the third type, in which the Hydrogen lines Hβ, Hγ, Hδ, Hϵ, Hζ were bright, and also two lines which appear to coincide with the bright bands in the spectrum of γ Velorum at λ 4656 and λ 4691. This spectrum, therefore, closely resembles that of Nova Sagittarii, and also of Nova Geminorum. A photograph taken on July 14, 1898, confirms the presence of the bright lines, while another taken on August 28, 1894, showed that at that time the spectrum was of Class K, with no evidence of bright lines.

From an examination of the photometric light curve of the star it was noticed that there was a remarkable increase during the year 1898. Before 1891 the magnitude, as determined photographically, was 10·9; it then increased gradually about half a magnitude to 10·4 in 1893, and retained this until 1897. In 1898 it was at first faint (10·8) until May 31. A month later, on June 30, it was 7·7, more than three magnitudes brighter, and after that it decreased regularly about a magnitude a month until October 8, when it again reached the value 10·8. The following year, 1899, it remained faint at 10·6, but in April, 1900, it again brightened to 9·3, diminishing to 10·0 in September of that year. Since then the variations have been only slight.

An examination of several good chart plates shows only one star in this position, and both the spectrum and light curves thus indicate that this object should be regarded as a nova rather than a variable star. In this case its proper designation would be *Nova Ophiuchi No.* 3, the new stars of 1604 and 1848 having also appeared in the same constellation.

Observations of Helium Absorption in the Solar Spectrum.

The number of occasions on which reliable observations have been made of the absorption spectrum of helium in the solar spectrum are so few that considerable importance must be attached to all authenticated instances. Probably the first recorded determination was that by Young on 22nd September, 1870. A few months ago a paper was read before the Royal Astronomical Society by Professor A. Fowler, in which he recorded having distinctly seen the dark D_3 line of Helium in the neighbourhood of the great sunspot of February, 1905.

Quite recently Dr. H. Kreussler, of Berlin, has published an account of two good observations of the phenomenon, obtained on the 12th and 13th June, 1904. The instrument used was a 6-inch reflecting telescope, with a spectroscope magnifying 8 diameters, the slit being in the region of the penumbra of a large spot. It was noticed that the faculæ surrounding the sunspots were very bright on both days.

He suggests that the present appearance of this peculiarity, considered with the above-mentioned observation of Professor Young, appears to indicate that the phenomenon may be characteristic of the period of maximum sunspot activity.

Comet 1905 (a).

The following elliptic elements for the orbit of the Comet 1905 (a) have been determined by Herr A. Wedemeyer from a computation of the observations obtained on March 26 at Nice, and on April 8, 28, at Vienna:—

ELEMENTS.

T = 1905 April 4·0991 Berlin Mean Time.
ω = 358° 13′ 20″·3
Ω = 157 23 27·8 } 1905·0
ι = 40 14 38·4
log. e = 9·988506
log. q = 0·047307
log. a = 1·630354
U = 279 years.

EPHEMERIS FOR 12 H. BERLIN MEAN TIME.

Date.	Right Ascension.	Declination.
	h. m. s.	° ′
July 1 ..	13 20 11	+ 39 44·1
,, 3 ..	25 39	39 2·1
,, 5 ..	30 58	38 20·0
,, 7 ..	36 10	37 37·7
,, 9 ..	41 14	36 55·3
,, 11 ..	13 46 10	+ 36 12·9

XUM

The New Tenth Satellite of Saturn.

Very little has been published since the discovery of the tenth satellite, but the details are now definitely stated in a communication from the Harvard College Observatory. The satellite was discovered by Professor W. H. Pickering at the Harvard College Observatory during the examination of a series of several photographic plates taken with the 24-inch Bruce telescope, selected from the set used in determining the orbit of Phœbe, the ninth satellite. The new satellite was detected on thirteen of these plates, and the previous announcement of the orbital motion being direct with a period of twenty-one days is confirmed; it is now stated to be nearer Saturn than Hyperion.

Photography of the Canals on Mars.

In a telegraphic communication to Professor E. C. Pickering, Mr. Lowell announces that numerous photographs of several of the dark canals on the planet Mars have recently been obtained at the Lowell Observatory by Mr. Lampland. Amongst others the following are specially mentioned as appearing quite distinctly, some being recognised on as many as twenty negatives:—Casius, Vexillium, Thoth, Cerberus, Helicon, Styx, Chaos, Liedeus.

CHEMICAL.

By C. A. MITCHELL, B.A. (Oxon.), F.I.C.

The Action of Light Upon Glass.

SIR WILLIAM CROOKES has communicated to the Royal Society (*Proceedings*, April, 1905) the results of experiments upon specimens of coloured glass sent to him by correspondents in Bolivia and Chili. The pieces of glass, which had originally been white, ranged in colour from pale amethyst to deep violet black, and the colour was not superficial but permeated the whole substance. It could be destroyed by heating the glass until it became soft, and restored again by exposure to the rays of radium. Manganese was found to be present in each case, and as the glass had been exposed to direct sunlight at an altitude of 4000 metres above the sea, Sir William concluded that it was possible that at that height there might be specially active rays in the sunlight which would convert the manganese present into the violet coloured manganic silicate. In his opinion the colour produced in glass by radium was the same as that caused by long exposure to the sun's rays. In the discussion Professor Judd called attention to the fact that the glass in some of the old greenhouses in Kew had changed from its original green colour (due to iron oxide), and after becoming colourless had gradually turned violet, and he attributed this to the manganese in the glass. It is interesting to note that Faraday, in 1825, recorded the occurrence of similar colorations in the windows of certain houses, now pulled down, in Blackfriars Road, after nine months' exposure to sunlight. Mr. W. H. Low, in a letter to the *Chemical News*, reports that he has observed numerous instances of the same kind in old window glass in many of the houses in Boston, U.S.A., the colours ranging from pink to violet and almost blue. The houses face east and are in low situations, so that the altitude cannot be one of the factors in this case. He asserts that a regular gradation in colour can be produced by covering successive portions of window glass with black paper and allowing each uncovered portion to be exposed to sunlight for a month longer than the preceding portion. Herr F. Fischer has also made experiments as to the influence of the light from an incandescent mercury lamp of special construction, the rays from which he concludes to be those of ultra-violet light. Of the eight kinds of glass tried, four, including a German lead glass and an English lead glass, were outwardly unchanged, while four were coloured a decided violet within 12 hours, the coloration becoming visible after 15 minutes. All of these contained manganese, whereas the uncoloured four were nearly free from compounds of that metal. Heat destroyed the colour, but it could be restored by a fresh exposure to the light. When the glass was covered with thin sheets of mica no coloration was produced, and it was therefore concluded that the effect was due to radiations of short wave length. Herr Fischer also suggests that the violet colours produced in glass by Röntgen tubes may be due to ultra-violet light acting on the manganese in the glass, and that the similar effect caused by radium may also be connected with radiations of short wave length.

The Prevention of Poisoning by Mercury Vapour.

The workmen in the quicksilver mines and, to a less extent, those engaged in the manufacture of barometers and other instruments in which mercury is used, are liable to suffer from a peculiar form of poisoning produced by continually breathing mercury vapour. The disease, which is known as "the trembles," or "mercurial tremor," affects the nervous system, so that the sufferer is attacked by fits of trembling whenever any attempt is made to use the muscles, and it eventually ends in death. In the mines in Spain, Austria, and America it is usual to remove workmen to other parts of the works comparatively free from the vapour, so soon as they show the characteristic signs of poisoning; but the Spaniards in South America did not pay even this amount of attention to their miners. A mining community was founded towards the close of the 16th century at Huancavelica, in Peru, to work the celebrated mine of St. Barbara, in which is a subterranean village with a church cut out of the cinnabar. This mine was a great source of profit to the Spanish, and it is estimated that during their rule thousands of the Indians driven to work there died of mercury poisoning. No serious attempt appears to have been made to grapple with this evil except that in certain mines better systems of ventilation have been adopted, and it has been left to an Italian chemist to devise a simple means of prevention. Dr. Tarugi has found that aluminium in a finely-divided state immediately absorbs mercury even when only traces of the metal are present in a large volume of air. The amalgam produced is very stable, and can be heated to 200° C., or twice the temperature of boiling water, without losing the slightest trace of mercury. This absorptive power of aluminium is so great that the reaction can be used as an extremely sensitive test for mercury. In order to utilise this property of aluminium in the prevention of mercury poisoning, Dr. Tarugi has devised a respirator containing several layers of very fine aluminium gauze, which will allow the air to pass whilst retaining every trace of mercury vapour. This respirator has been patented in Italy, Austria, and Spain, and will probably before long be adopted in all quicksilver mines.

The Consumption of Odoriferous Constituents by Plants.

The results of interesting experiments on basil plants have been published by MM. Charabot and Hébert. One set of plants were kept in the dark for six weeks and another under normal conditions for the same period. The amounts of essential oils (to which the perfume is due) were determined before and after the experiments, and it was found that they had increased twenty-fold in the plants kept under ordinary conditions, while there was a notable decrease in the case of the plants kept in the dark. Hence it appears that the odoriferous constituents of basil are not simply products of excretion, but that under certain conditions they can be utilised to supply some of the energy not given by the light or to form tissue.

GEOLOGICAL.

By EDWARD A. MARTIN, F.G.S.

Coal.

THE Report of the Royal Commission on Coal Supplies has served to emphasize one fact very clearly, namely, that in spite of all fears which have possessed the British people for forty years as to the possible exhaustion of our coalfields, such fears have very little reason for their existence, and at least for half a millennium, even with the present rate of consumption, there will be no shortage of supply. We are, in fact, only just at the beginning of the "coal-using age." In 1820 Britain raised but 20 millions of tons of coal. Now she raises 230 million tons a year. If she continue to use coal to

the same extent as now, she has five centuries before her, and during this period it may safely be said that no one will feel the gradual exhaustion which will be taking place. But the Commissioners point out in their report what other thoughtful men have pointed out before, that other considerations will come into play which will probably have the effect of reducing the rate of increase of output, until finally the immense existing output will actually decline. Not improbably by the time that our coal supplies are approaching exhaustion, the greater portion of the demand will have ceased, and other means of lighting and heating will exist other than that to be obtained from coal.

Foreign Coal.

When we look at deposits of coal which are found abroad we may be fairly astounded at the wealth which some continental countries possess, and it is as well that there should be a clear understanding that the foreign supplies of coal bear much the same proportion to our British supplies as an elephant does to a mouse. No human agency can ever exhaust the world's supplies. But frequently they are so situated as to be practically valueless. They are in a similar category to what the Commissioners called the "unproved" coalfields of Britain, and the seams at depths greater than 4000 feet, below which no mine is known to exist. China has rich possessions of coal. Many of the seams are near centres of population, and are easily worked. In the mountainous areas of western China coal-measures are found in great profusion, and seams from 30 feet thick and upward have been traced in a horizontal plane for 200 miles towards the Mongolian frontier. But at present they are practically valueless, and, like our own deep-lying seams, require engineering skill such as is not now to be found for their development.

The Age of Diplodocus.

At the official presentation to the Natural History Museum of the replica of *Diplodocus Carnegii*, the curator of the Carnegie Museum was reported to have alluded to the age of the monster Dinosaur as four thousand centuries. English geologists do not as a rule care to speak of the age of any particular formation or fossil in terms of years. Years are such insignificant items where geological ages are concerned, and every estimate so made is certain to be open to very great error. But it is impossible to conceive by what means of calculation a creature of Jurassic age can be said to be but 400,000 years old. Geologists have for years fretted under the reign of those physicists who say that no form of life was possible on this earth before 100 millions of years ago. And in view of possible discoveries in connection with radio-active bodies in the future, it becomes increasingly difficult to place a period either to the time at which the sun began to give out heat, or when it will cease to do so. Geologists will, I am convinced, find themselves compelled to tear themselves away from all restrictions of time placed upon them by those who are first physicists and after geologists. The more the facts of geology are borne in upon one, the more, as it seems to me, is it impossible to see the possibility of all the great geological phenomena having taken place in less than 250 millions of years. By a process of calculation on this basis, the age of the *Diplodocus*, namely, the Jurassic age, came to a close 41½ millions of years ago. This is, however, only an estimate; but it is likely to be nearer the truth than the utterly insufficient number of years previously given.

ORNITHOLOGICAL.

By W. P. PYCRAFT, A.L.S., F.Z.S., M.B.O.U., &c.

The Habits of the Kagu.

THE Kagu (*Rhinochætus jubatus*) is one of those rare and aberrant types which seems likely to disappear from off the face of the earth, leaving but little save its skin and a few particulars of its anatomy for the ornithologist of the future to remember it by. Though a native of New Caledonia, according to some, its nearest ally is the equally rare and unknown Mesites or Madagascar Kagu, while others regard it as more nearly related to the Sun-bird (*Eurypga helias*) of South America. This, too, is an aberrant type.

All that appears to be known of its eggs and nesting habits we owe to observations made on a pair of these birds in captivity and recorded in the current number of the *Emu*. A pair, kept in an aviary at Sydney, built a nest of a few coarse sticks and leaves, in which was laid a single egg. This was then surrounded by more sticks and brooded continually by the cock bird, relieved occasionally, it is believed, and during the night, by the female. Incubation lasts five weeks. If the egg be removed, another is laid, and this will be replaced, if taken away, two or three times. The egg is here described as bearing a striking resemblance to that of a gull, from which it differed only in the fine texture of the shell.

This is curious, inasmuch as an egg dropped by one of these birds in the Zoological Gardens in London, and now in the British Museum, bears as close a resemblance to that of the Southern Courlan (*Aramus scolopaceus*), being perfectly elliptical in shape, cream-coloured, spotted and blotched with dark brown and purplish grey. It differs from the Courlan's egg, however, in being without gloss, and slightly rough in texture.

The Hunting Tactics of the Sea Eagle.

A writer in the *Field* (June 17) gives a short but interesting account of his observations on the habits of the white-tailed Sea Eagle (*Haliætus albicilla*) in Greenland. In summer its principal food is salmon, varied by sea-birds common along the inlets. In autumn, when the salmon have ascended to the lakes, the birds resort to the sea. They appear to have a special fondness for eider duck, which are taken by strategy. "Stationed near the water in a commanding position, with a background of cliff, the colour of which assimilates with that of the eagle's plumage, he sits motionless, until a flock of duck settles near him. After a time one or two dive in search of food, but not until all have gone under together does the eagle make a sign. He then glides swiftly to the spot, and circles over it close to the water; with his sharp eye he can detect the birds before they reach the surface. At first he is not usually successful, for as soon as they become aware of the presence of the enemy, they dive again instantly; but in time they are obliged to come up for air, and then one of them becomes an easy victim." A full-grown eider drake is easily lifted up and borne away in the talons of this powerful pirate. Most of the sea-fowl, it is interesting to note, readily distinguish between the Sea-Eagle and the falcon when on the wing and vary their tactics, and escape capture accordingly. Thus, when pursued by the falcon they dive, but in fleeing from the eagle they depend on their ability to turn rapidly on the wing, which the eagle is unable to do.

Golden Orioles in Stratford.

Mr. Reginald Hudson, in *Nature Notes* for June, records the fact that a pair of Golden Orioles were seen in a garden on April 27, at Shottery. Whether they have so far been allowed to remain unmolested, we cannot say; if they have, in all probability they will nest here. As many readers are doubtless aware, the Golden Oriole has more than once reared its young in these islands, and were they not so mercilessly shot down on every occasion, these gorgeous birds would doubtless more frequently visit us.

Iceland Gull in the Moy Estuary.

Mr. R. Warren, in a somewhat sarcastic note in the *Irish Naturalist* for June, records the fact that an immature Iceland Gull, *Larus leucopterus*, was shot by himself in the Moy Estuary on April 26. He gives the following measurements:—Length, 21½ ins.; capus, 16 ins.; tarsus, 2 ins.

Tufted Duck Breeding in Co. Mayo.

According to the *Field* (June 17): Three or four pairs of Tufted Ducks, *Fuligula cristata*, appear to be breeding this year on Lough Conn, where a nest of eleven eggs was seen by Mr. S. Scroope. The nest was identified by a piece of down sent by the Editor of the *Field* to Mr. Whittaker, of Rainworth. Thus the extended breeding range of this bird in Ireland, to which Mr. Ussher has drawn attention (*Birds of Ireland*), is confirmed. In the volume just referred to, it is stated that the portions of Ireland where this bird is not known to breed include, amongst others, "the province of Connaught west of the Shannon, and Lough Arrow, in Sligo." Lough Conn lies a little less than 30 miles from Lough Arrow.

XUM

PHYSICAL.

By ALFRED W. PORTER, B.Sc.

Ether Drift.

THE question as to whether or not the earth carries the *ether* near it in its journey through space is one of very great theoretical importance, and the last word upon it has not yet been said. The fact that stellar aberration has the same value whether determined by means of an ordinary telescope or by one filled with water can most simply be explained by supposing that *in the water* the ether is carried forward with a portion only of the earth's velocity, while in the air round the telescope it is sensibly at rest in space.

On the other hand, the results of Michelson's and Morley's experiments with their interferometer can be accounted for most simply by supposing that both the earth and the ether near it are moving with the same speed; that is to say, that the earth drags the surrounding ether with it in much the same way as that by which a layer of air is carried by a projectile.

Experiments by Sir O. Lodge on whirling massive discs prove that they at any rate exert no perceptible drag; and, consequently, if the earth does so, it must be due to its great magnitude. It was pointed out by FitzGerald (and independently by Lorentz) that if we suppose that the length of a body when set moving is shortened in the direction of that motion then Michelson and Morley's experiments do not imply the absence of relative motion; in fact, if the shortening takes place to an appropriate extent, they do not show that the ether is moved at all. Other experiments have also been made which seem to require that this supposed shortening is real.

Morley has recently (*Philosophical Magazine*, May, 1905) varied his previous investigation with the object of testing whether the compensation which cancels the effect due to relative motion is complete in every case. It is the shrinkage of the base plate of his apparatus which may come into play; and, besides improving the apparatus by increasing the sensitiveness, he has changed the material of this plate from iron to wood. There is still absence of any indication of relative motion of earth and ether, and the proportional shortening must therefore be the same as in the previous experiments.

It may at first sight seem unlikely that two such different materials should be equally affected. But the true explanation must be that it is not the nature of the molecule (or molecular aggregate) or even that of the chemical atom which determines it; for these are very different in the two cases. It is something more fine grained than these, and this something must be essentially identical (at any rate as far as this particular property goes) in both these bodies. In fact, the result is an additional piece of evidence in favour of the theory that all atoms are built up of smaller particles, each one of which is of the same kind.

A New Interrupter.

Workers with induction coils know too well the trouble there is with the interrupter, whatever its type. The difficulty is to a very large extent removed in the Grisson Resonance Apparatus which is put on the market by Messrs. Isenthal and Co. The intermittence of the current in the primary coil is produced by means of a modified commutator which is spun round by a ¼-H.P. electric motor. The commutator interchanges, with a frequency up to 200 times a second, the connections of the armatures of a condenser with the primary coil and battery (or other unidirectional source) which are in series with it. At each reversal the battery sends through the coil a quantity of electricity equal to twice the maximum charge of the condenser, and these impulses must always go the same way through the primary. Since the current into the condenser rises very fast (owing to the small inductance of the primary) and then falls off much more gradually, the quantity that flows through the secondary is nearly, if not perfectly, unidirectional and hence is suitable for exciting X-ray bulbs. The essential reason of the efficiency of the commutation arises from the fact that the reversal takes place when the current into the condenser is zero, or at any rate very small; in consequence there is absolutely no visible sparking at it. This is the case through the whole working range of speed, for it is at most the tail end only of the flow that is cut off.

Instead of commutating the condenser it may be the battery that is so treated. The flow through the primary is then alternately of opposite signs, and the flow through the secondary is also alternating. In this case by suitably choosing the inductances, the condition of resonance may be set up at particular speeds. In fact, by this means from the primary circuit alone, an e.m.f. of much higher than 100 volts can be obtained by the use of a 100-volt circuit.

The condensers employed are electrolytic condensers consisting of aluminium plates immersed in an electrolyte contained in a seamless steel vessel. Each of these is capable of furnishing a current of 15 amperes from a 110-volt lighting circuit. Greater currents can be obtained by connecting a number in parallel. Such condensers are very compact, the dielectric being the thin film of aluminium oxide which forms on the plates.

When the coil is replaced by a suitably wound electromagnet a powerful alternating magnetic field is produced which acts on the nervous system. If the forehead is placed close to one of its poles a flickering sensation of light is experienced.

The spinning commutator is made in a thoroughly workmanlike way; its design is of an engineering type contrary to what is only too frequently turned out by instrument makers.

ZOOLOGICAL.

By R. LYDEKKER.

The Smallest British Dinosaur.

THE Dinosaurian reptiles—both small and great—appear to be attracting a considerable amount of attention at the present time. One of the latest contributions to the literature of the subject is a note in the May number of the *Geological Magazine*, by Baron Francis Nopcsa, on the skull of *Hypsilophodon*, a species from the Wealden of the Isle of Wight, of about the size of a fox, and it not actually the most diminutive, at all events one of the smallest representatives of the group. Despite its diminutive size, it appears to have walked on its hind legs after the fashion of its gigantic cousin, the iguanodon, of the same epoch. In a specimen preserved in the British Museum, Baron Nopcsa shows that what had been taken for the skull of the creature is really its lower jaw, and that the structures described as bony plates from the white of the eye are really the teeth. Consequently, there is every reason to believe that all dinosaurs, like their relatives, the crocodiles, lacked a ring of bony plates in the white of the eye.

The English Water-Shrew.

Captain Barrett-Hamilton, in a recent issue of the *Annals and Magazine of Natural History*, points out that the British representative of the water-shrew differs from the typical continental form of that animal to an extent sufficient to permit it to rank as a distinct local race, for which the name *Neomys fodiens ciliatus* is available. There are likewise several continental races of the species, the Scandinavian, and other mountain forms, in common with the one from the British Islands, being dull-coloured creatures, in comparison with those inhabiting the lowlands.

Face-gland Vestiges in the Horse.

In a paper published in the May number of the *Annals and Magazine of Natural History*, Mr. R. I. Pocock considers that the depression so frequently found in the skulls of Arab horses and thoroughbreds, immediately in front of the eye, has nothing to do with the face-gland of the extinct hipparions, but is merely for muscular attachment. If this be so, the theory as to the importance of this depression in regard to to the origin of Arabs and thoroughbreds is wiped out at one stroke. Despite the fact that the existence of functional face-glands has been recorded in two living horses, the author considers himself justified in stating that the modern horse never exhibits any trace of the hipparion's face-gland.

XUM

Photography.

Pure and Applied.

By CHAPMAN JONES, F.I.C., F.C.S., &c.

Intensification with Chromium Salts.—The method of intensification referred to in the "Science Year Book" as having been recently suggested by Mr. J. S. Teape and by Messrs. Welborne Piper and D. J. Carnegie, has been further examined by the latter gentlemen. The process consists in rehalogenising the silver image by means of a solution of potassium bichromate containing hydrochloric acid, and then reducing the silver salt formed with a developer. The apparently anomalous result that the image is so made much more dense is due, as might have been anticipated, to the deposition of a chromium compound, produced doubtless by the reduction of the chromate by the metallic silver. This is a clear guide to the precautions that are necessary to ensure success, and accounts for the very different results that different formulæ give—from nothing up to a very large gain in density. Messrs. Piper and Carnegie in their last communication ("Amateur Photographer," XLI., 453) recommend potassium bichromate 10 grains, hydrochloric acid (s.g. 1.16) 5 minims, and water to one ounce, as the most generally useful bleaching solution, an increase in acid diminishing the increase of density, and a smaller quantity (preferably with dilution of the solution) increasing it. Amidol is preferred to other developers because it is rapid in action and needs little or no alkali.

The authors consider this process far preferable to any mercury process, including even the mercury and ferrous oxalate method. Here I must join issue with them, and for two distinct reasons, either of which would, in my opinion, be sufficient to establish the superiority of the mercury and ferrous oxalate method. In the first place, the chromium compound that is added to the image is soluble in acids and is produced always in an acid solution. So far as at present known, the presence of a solvent of the material that constitutes the image renders the production of the image uncertain. That is, one cannot be sure of the same increase of density following the same procedure so far as one is able to make it the same; and one can never be sure that the presence of the solvent does not lead to a reduction effect on the image, and if it should do so it is scarcely possible for it to be proportional throughout. The mercury and ammonia method has a solvent present, namely, the ammonia, and this method never gives a proportional result. Then, secondly, the material added to the image has a "brownish buff" colour, according to the authors, and this is very much the colour that one would expect the chromium compound to be. It is always undesirable to introduce a coloured substance into a negative, because a coloured image will produce different results according to the colour sensitiveness of the printing paper, and also, it may be added, according to the nature of the light used. A neutral tinted image graduates all lights alike, but it is practically impossible to calculate the effect of a coloured image. Therefore it seems to me that while other methods have advantages in special cases and are good enough for negatives that have no particular value, the mercury and ferrous oxalate still remains the only scientifically reliable method of intensification.

Reduction with Cobaltic Salts.—Mr. Harry E. Smith (jour. Royal Phot. Soc., May, p. 185) has been experimenting with certain ammonio-cobaltic salts and analogous compounds as reducers for negatives and silver prints, and finds that the tetra-ammonio-cobaltic potassium nitrite, a salt prepared by Erdmann a generation or so ago, is the most satisfactory of those he has tried. Erdmann's salt will shortly be on the photographic market, its use as a reducer having been patented. The formula suggested is a quarter per cent. solution of the salt in a seven or eight per cent. solution of sulphuric acid, and the negative or print after reduction is soaked for three minutes in a ten per cent. ammonia solution, and finally washed. Mr. Smith claims for this reducer that it attacks the "denser deposits of silver much more readily than the half-tone and lighter deposits, so that it is particularly useful in softening the scale of gradation of hard negatives or prints." It appears to be distinctly slow in action. From Mr. Smith's communication it is not clear whether what he calls its "selective" action, that is, the fact that it does not attack the thinner deposits unduly as most reducers are liable to do, is due simply to the slowness of the action or to some peculiar property wherein it may be likened to the persulphates. If the latter is the case, then an investigation of the chemistry of the change during reduction may be of considerable interest as helping to show why the persulphates produce exceptional results, for we do not yet know what the action of the persulphates is from a chemical point of view. I consider that in all cases we ought to know the chemistry of such changes as these before trusting valuable negatives to the action of the proposed reagents. Of course, negatives that have no permanent value do not require such consideration. I hope that Mr. Smith will give us the results of further investigation, and determine the character of the brownish substance that is sometimes obvious after reduction, and for the removal of which the ammonia bath is desirable.

The Stability of Photographs.—The action of light and air upon photographs is often regarded from a too empirical point of view, its effect being judged of merely by the visible change that results. Light, in some cases, causes a loss of colour or bleaching, as in the fading of dyes that is so obvious in curtains, carpets, clothes, and dyed fabrics in general; and in others a production of colour as in some methods of photographic printing. If the simple object is either to bleach or to produce colour, then, of course, the observation of the colour-change may be a sufficient guide to the progress of the action, but if the aim is to test for stability, neither the presence nor the absence of a visible change is sufficient to justify any definite conclusion. There may be even much alteration in appearance while the image remains unaffected, as in the case of platinum prints carelessly made or pasted on to inferior mounts; and on the other hand, there may be considerable change that is not manifested by any notable alteration in either tint or depth of colour. The only way to settle such questions is to investigate the composition of the image by chemical means as well as its appearance by optical means.

Correspondence.—Bryan, E. H.—The method of development you propose would not be advantageous for several reasons. The practical aspects of photography during the visit of the British Association to South Africa will be dealt with in the special number of this journal that will shortly be issued.

XUM

MICROSCOPY

Conducted by F. SHILLINGTON SCALES, F.R.M.S.

Royal Microscopical Society.

May 17th.—At 20, Hanover Square, Dr. Dukinfield H. Scott, F.R.S., President, in the chair. Mr. Rousselet described an old microscope of the Culpeper-Scarlet type which had been presented to the Society by Mr. J. E. Hazelwood. It was signed "Nath. Adams, Optician to his Royal Highness Frederick Prince of Wales Fecit." The date was probably about 1740, and it differed from others of the type in having four pillars instead of the usual three. Mr. Rousselet also described an old Adams Lucernal microscope, made by Adams' successors, W. and S. Jones, which had been presented to the Society in January by Lieut.-Col. Tupman, and was exhibited in the room. The body consisted of a mahogany box of the form of a frustum of a pyramid about 17 ins. long and 7 ins. square at the base lying horizontally. The objective was carried in a sliding tube at the small end, and an eye-piece of two lenses about 5 ins. in diameter was placed at the other end. The stage had vertical and horizontal motions, and there was a condensing system of two independent lenses behind it. The curious feature about the instrument was the method of observing the image, which was by means of an aperture about ¼ in. in diameter in a small disc carried by an arm that was attached to a telescopic rod projecting from below the instrument. The distance of the disc from the eye-piece could thus be adjusted until the best effect was obtained. On looking through the disc, which in this instance was about 14 ins. from the eye-piece, a very fair image of an object placed on the stage was seen in the eye lens. A communication received from Mr. D. D. Jackson, of New York, on "The Movements of Diatoms and other Microscopic Plants," was read. Mr. Jackson described the interesting observations and ingenious experiments made by him, some with artificial diatoms, which led him to conclude that the movements referred to are caused by the escape of oxygen gas evolved in these organisms. Slides of Oribatidae were exhibited from the collection presented to the Society some twenty years ago by Mr. A. D. Michael, who, on the invitation of the President, made some remarks upon that family of the Acarina.

The Microscope in the Witness Box.

The use of the microscope as an aid to the scientific worker is apparent to everyone, and it is, of course, universally used in scientific laboratories. It will occur to most people that it must have many uses as a means of detecting adulteration in food, and that, therefore, it is a valuable aid to the public analyst, but it is, perhaps, not so evident that it can give equally valuable help and testimony in the witness box. An elementary example of the help given by the microscope in forensic medicine is its use in detecting blood stains. The minute red blood discs which give the red colour to the human blood are not more than seven one-thousandths of a millimetre in diameter, and are obviously microscopic objects, while they can only be seen in undried blood, but the microscope can be used to give evidence of blood stains in quite another way. Suspected blood stains on clothing, etc., can be treated with a little alkali, evaporated to dryness, and then heated with acetic acid and a minute amount of sodium chloride, with the result that small but characteristic crystals,

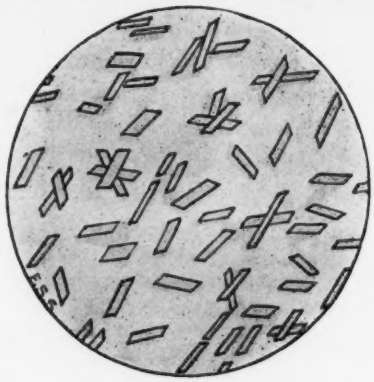

Fig. 1.

known as "haemin crystals," make their appearance. (Fig. 1, much magnified.)

This, however, is more an example of laboratory work than of a demonstration in open court, but some very striking examples of what can be shown by the microscope in cases of suspected forgery were given by Mr. Albert S. Osborn a year and a half ago, in what was unfortunately the last number of the American *Journal of Applied Microscopy*, and I reproduce some of his excellent illustrations here because they will, I think, interest readers in this country who have not seen the original paper, expressing my obligations to Mr. Osborn for both illustrations and subject matter.

For instance, as Mr. Osborn points out, it is manifest that if a paper were folded, and it could be demonstrated that part of the writing was made after such folding, strong suspicion would be cast upon the document. This might be shown by a tiny amount of ink spreading into the crease and even reaching the other side of the paper, and it would be quite unmistakable.

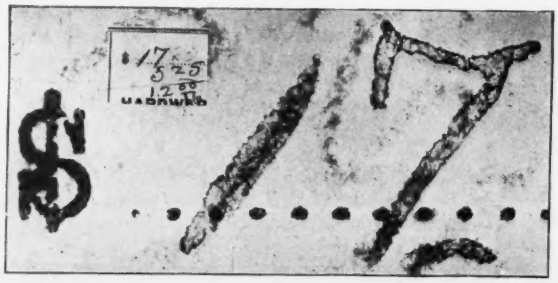

Fig. 2.

Similarly, fraudulent additions to documents may be shown to have been written with a different pen, or at a different time, or under different conditions, by measuring the width of the unshaded strokes and observing that they differ from those of the original writing. Such measurements are readily made up to the ten-thousandth of an inch, or less.

Still more striking are additions made to letters as in Fig. 2, where the numeral I in II has been changed into 7 by the addition of a stroke at the top.

A fraudulent addition or interlineation may touch the top of another letter and thus give evidence against itself. In Fig. 3 it will be seen that the words "in full

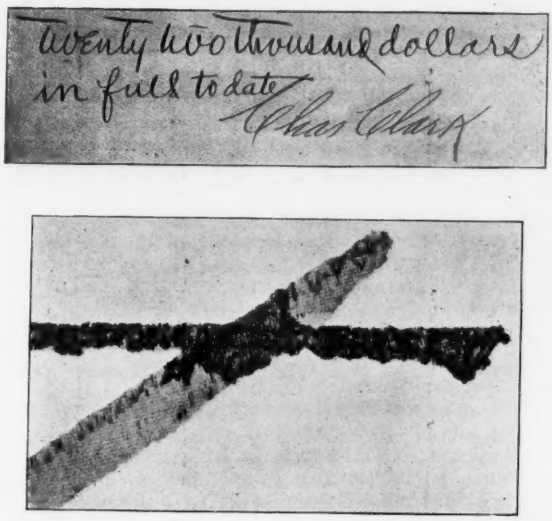

Fig. 3.

to date" have been manifestly added after the signature of the receipt, as shown by the crossing of the "t" in "date" running over and into the top of the initial letter of the signature. In this case the whole question was whether the receipt was given for a definite amount or "in full to date."

Forged signatures are frequently first carefully outlined in pencil before being inked in. In such cases the pencil marks can be shown under the microscope not properly covered, and with the graphite caught in the ink film. Any further attempt to erase the pencil marks would probably have more or less altered the superficial appearance of the paper. Forged signatures carefully and laboriously drawn from a model with frequent liftings or stoppings of the pen show the over-lapping of lines and uneven distribution of the ink with astonishing clearness. The tint also of the ink may show on comparison that a document purporting to be several years old is really only as many days old. Even in typewriting, comparisons by means of the microscope may show numerous discrepancies and differences.

Perforations are often used to prevent fraud, but these have been known to be laboriously filled in and new ones made. The microscope, however, readily exposes such a fraud, as is shown in Fig. 4.

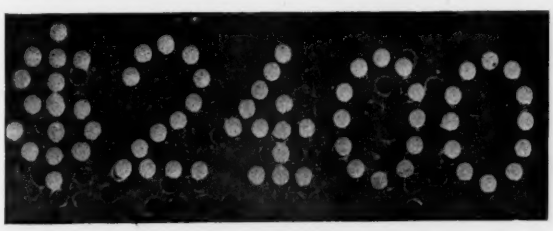

Fig. 4.

Mr. Osborn calls attention to the fact that high powers are not necessary to detect the majority of such cases of alteration of documents. A $\frac{1}{6}$ in. is about as high a power as is needed, but there must be good substage illumination by means of a condenser, and means of illuminating opaque objects by a bull's-eye or other wise. Polarizing prisms may be useful in certain cases of paper fibre examination, and micrometer apparatus is essential, as well as drawing apparatus. Photo-micrography is of most valuable service in making exact reproductions.

The microscope should have a large stage, and for examining some kinds of disputed documents the microscope tube may be mounted with advantage on a special stand without a stage, so as to give a large open field directly under the objective. In this way it is easy to examine the middle or any other part of a large document. The examination of crossed lines, traces of pencil marks, edges of lines, paper fibres, etc.; the investigation of evidences of re-touching, and the examination of ink conditions may require a high power objective, but for examining writing as such a magnification of from ten to fifty diameters is ample. Photo-micrographs are frequently useful, and may, in certain cases, be conclusive evidence. The general magnification of such photo-micrographs is from twenty to fifty diameters, but the objective must be flat in the field and a long camera length is preferable to eye-piecing. A camera lucida attachment for drawing directly from the image in the microscope is useful for making illustrations and outlines, and in measuring.

Objectives with Safety Springs.

Beginners and elementary students find the very short working distance of high power objectives a source of danger either to the front lens of the objective or to the cover-glass of the slide, and even more experienced workers are sometimes liable to misfortunes of this nature. To obviate this C. Reichert has fitted Bourgnet's Spring Safety Action to all his high power objectives from $\frac{1}{8}$ in. upwards. The optical part of the objective is mounted in such a way as to slide bodily within an outer projecting case, the front lens projecting through a circular aperture in the front of this case and kept in position by a spiral spring above, which rests against a collar inside. Under ordinary circumstances the elasticity of this spring keeps the objective in proper adjustment, but in case of contact between lens and cover-glass the optical part is pushed into its sheath.

Hanging Drop Preparations.

Mr. J. R. Collins gives in the *British Medical Journal* a very simple method of making a hanging-drop preparation which obviates the usual method of building up a moist cell with rings of wet blotting-paper. A small rubber elastic band of suitable size and thickness is smeared with vaseline on one side, and this side is then placed on the slide. The upper side of the rubber band is now likewise smeared with vaseline and the cover-glass with its hanging-drop applied to it. An air-tight cell is thus easily made.

[*Communications and enquiries on Microscopical matters are invited and should be addressed to F. Shillington Scales, "Jersey," St. Barnabas Road, Cambridge.*]

The Face of the Sky for July.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the Sun rises at 3.48, and sets at 8.18; on the 31st he rises at 4.23, and sets at 7.49.

The earth is at its greatest distance from the Sun on the 3rd, when the apparent diameter of the Sun is a minimum, being 31′ 30″·7.

Solar activity is well shown by the large number of sunspots and bright prominences.

The position of the Sun's axis and equator, required for physical observations of the Sun, is indicated in the following table:—

Date.	Axis inclined from N. point.	Equator S. of Centre of disc.
July 1 ..	2° 43′ W.	3° 3′
,, 10 ..	1° 23′ E.	4° 0′
,, 20 ..	5° 51′ E.	4° 56′
,, 30 ..	10° 6′ E.	5° 45′

THE MOON:—

Date.	Phases.	H. M.
July 2 ..	● New Moon	5 50 p.m.
,, 9 ..	☽ First Quarter	5 46 p.m.
,, 16 ..	○ Full Moon	3 32 p.m.
,, 24 ..	☾ Last Quarter	1 9 p.m.
July 10 ..	Perigee 229,700 miles.	5 0 a.m.
,, 23 ..	Apogee 251,200 ,,	6 30 p.m.

OCCULTATIONS.—There are no stars brighter than the 6th magnitude occulted during this month, as seen from Greenwich.

THE PLANETS.—Mercury is an evening star in Gemini and Cancer, but is not favourably situated for observation during the early part of the month; towards the end of the month he is approaching an eastern elongation from the Sun, but even then he only sets one hour after sunset.

Venus is a bright object in the morning sky, looking east, rising about 1.10 a.m. on the 15th; as seen in the telescope the phase appears that of "half moon," the apparent diameter of the disc being 22″. Towards the end of the month the planet is skirting the northern boundary of the Hyades.

Mars is on the meridian just before sunset, but on account of increasing distance from the earth his lustre is diminishing. The planet is not well placed for observation on account of his great southerly declination, and as this is increasing his meridian altitude is becoming less. The apparent diameter of the planet is 12″ and the disc is slightly gibbous, 0·88 being illuminated. On the 15th the planet sets about 11.35 p.m.

Jupiter is a morning star in Taurus, and is situated a few degrees south of the Pleiades; on the 22nd he rises about midnight. On the 3rd and 4th, Jupiter and Venus will form a brilliant pair in the morning sky, being less than 3° apart, Jupiter being to the north. The apparent polar diameter of the planet is 33″.

Saturn is coming into a more suitable position for observation in the evenings; he rises about 10.50 p.m. on the 1st and about 8.40 p.m. on the 31st. Near the middle of the month the planet is on the meridian about 2.40 a.m.; he is describing a short retrograde path near σ Aquarii.

We are looking down on the northern surface of the ring at an angle of 9°, and the apparent diameters of the outer major and minor axes are 43″ and 6″·5 respectively, whilst the polar diameter of the ball is 17″·0.

Uranus is becoming more favourably situated for observation at convenient times, being on the meridian about 10.30 p.m. on the 15th. He is situated about 2½° south of 4th magnitude star μ Sagittarii, and can easily be seen with an opera glass, though somewhat difficult to see with the naked eye.

Neptune is out of range for observation.

Meteors.—The most conspicuous shower is the δ Aquarids, which occurs on the 28th; they are slow moving and long. The radiant is situated in R.A. XXII.^{h} 6^m, Dec. S. 11°.

TELESCOPIC OBJECTS:—

Double Stars.—5 Serpentis, XV.^{h} 13^m, N. 2° 13′, mags. 5·1, 10; separation 10″.

β Serpentis, XV.^{h} 41^m, N. 15° 44′, mags. 3·8, 10; separation 31″.

θ Serpentis, XVIII.^{h} 51^m, N. 4° 4′, mags. 4·0, 4·2; separation 21″·6. Both are yellow, the primary being of a paler yellow than the smaller star.

ξ Cephei XXII.^{h} 1^m, N. 64° 8′, mags. 4·7, 7; separation 6″.

δ Cephei XXII.^{h} 26^m, N. 57° 56′, mags. 4·2, 7; separation 40″. A pretty pair for small telescopes, yellow and blue. It is also a variable star; period 5^d 9^h, with a quick rise to maximum in 1^d 9^h.

Clusters.—M5 (Libra). A compact cluster situated about one-third of a degree north of the double star 5 Serpentis; when seen through a pair of opera glasses it appears like a large nebulous star.

N.G.C. 6633. Cluster in Serpens. About one-third of the way between θ Serpentis and α Ophiuchi (visible to the naked eye).

New Preservative for Animal Products.

MR. FLETCHER, chemist and analyst of Sydney, New South Wales, has during recent years introduced a new process for preserving meats and other organic substances. The food products are placed in an airtight chamber, and treated by a gas for six or eight hours. No liquids or solids come into actual contact with the meat. An unskilled workman can operate the chamber, and the cost is said to be very small. It is further alleged that no taste from the curing process has yet been noticed, and no analyst has discovered any preservative whatever in the goods cured. Beef up to the present has not been cured satisfactorily, and the process is not effectual with fruit or milk, but success is claimed for the treatment of mutton, bacon, sausages, &c. The treatment is simple and rapid. No freezing is necessary, and no borax or kindred preservatives, and it is stated that food after treatment can be shipped in safety and remain in a fresh condition during transport. Since the latter part of 1902 it is stated that the process has been tested continuously, and that meat, sausages, &c., cured by it in April, 1903, are still sound and good.

Knowledge & Scientific News

A MONTHLY JOURNAL OF SCIENCE.

Conducted by MAJOR B. BADEN-POWELL, F.R.A.S., and E. S. GREW, M.A.

CONTENTS AND NOTICES.—See page V.

THE BRITISH ASSOCIATION.

MEETING IN SOUTH AFRICA.

PROFESSOR GEORGE HOWARD DARWIN, who, on August 15, at Cape Town, will be installed PRESIDENT of the British Association for the Advancement of Science, in succession to the Right Hon. A. J. Balfour, M.P., is the second son of the late Charles Robert Darwin, the eminent naturalist—the "Copernicus of biology." Born in 1845, at Down, the Kentish home of the Darwins, he entered Trinity College, Cambridge, and in 1868 he graduated as Second Wrangler and Second Smith's Prizeman. In the same year he was elected Fellow of his College, and in 1883 was elected to the Plumian Professorship of Astronomy and Experimental Philosophy in the University of Cambridge, vacant by the death of the Rev. James Challis, M.A., F.R.S., a position which he still holds.

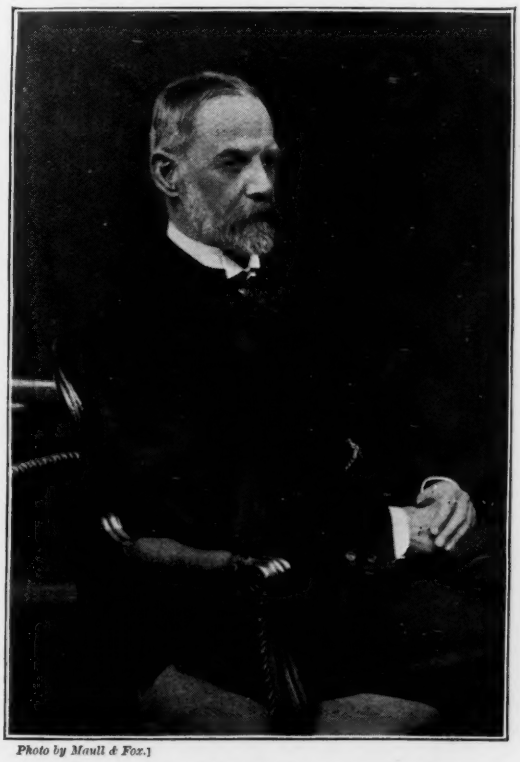

Photo by Maull & Fox.]

PROF. G. H. DARWIN, LL.D., F.R.S., President.

One of the earliest of Professor Darwin's contributions to science appeared in the "Philosophical Transactions" entitled "On the Influence of Geological Changes on the Earth's Axis of Rotation"; his most recent was read before the Royal Society on May 18—"On Lesage's Theory of Gravitation and the Repulsion of Light." In a series of papers he has dealt exhaustively with the theory and prediction of the tides, especially with reference to Indian tidal observational work. The trend of his studies will, however, be manifest in his Presidential Address. This will discuss the general principles involved in theories of evolution, with special reference to the world of inanimate matter, and will be illustrated by means of various theories of the intimate constitution of matter and of cosmical evolution.

Professor Darwin has been honoured by many scientific societies both at home and abroad. In 1879 he was elected a Fellow of the Royal Society, receiving in 1884 the Royal medal of that body, the grounds of the award being his mathematical investigations of the secular changes in the relative motions of the earth, moon, and sun, due to internal consumption of energy; and for work on the harmonic analysis of tidal observations. He is a Foreign Member of the American Academy of Arts and Sciences, and of the Reale Accademia dei Lincei, Rome; and an Honorary Member of the University of Padua. The latest recognition of his position in the world of science was that afforded by the conferment of the degree of Doctor of Science, *honoris causa*, at the Encænia, Oxford University, on June 28 last, when he was admitted with the significant salutation, "Docta docti progenies patris."

XUM

The British Association:

ITS ORIGIN AND PROGRESS.

Objects of the Association.—To give a stronger impulse and a more systematic direction to scientific inquiry—to promote the intercourse of those who cultivate Science in different parts of the British Empire with one another and with foreign philosophers—to obtain a more general attention to the objects of science, and a removal of any disadvantages of a public kind which impede its progress.

THE British Association for the Advancement of Science is something more than an asset of English science; it may now be truly ranked as an asset of the British Empire. Thus it would seem to have fulfilled the aspirations of those, its founders, "merchants of light," if we may use the term, who cherished a far-seeing vision of ultimate growth and power. We may, however, be sure that none ever dreamed that the peripatetic habits of the Association would extend to so remote a centre as South Africa, now, moreover, an integral part of the King's dominions.

The story of how the Association sprang into existence, and what it has effected, is, or should be, a familiar one to Englishmen, for the history of the British Association during the seventy-four years of its hardy life is in no small degree the history, not only of the progress and range of scientific enquiry in the land of their birth, but a commanding record for an equivalent period of personal achievements. To emphasise this it will suffice to recall such names as Brewster, Sedgwick, Murchison, Owen, Lyell, Faraday, Joule, Darwin, Hooker (happily still among us), Thomson (Lord Kelvin), Stokes, Tyndall, and Huxley, each of whom has given us abiding and profound conceptions in science and the problems of life. Surely every schoolboy in England might find a text of instruction here!

On two previous occasions only has the Association migrated from the Mother Country in order to hold its annual Congress. The first of these was in 1884 when it crossed the Atlantic to meet at Montreal. Lord Rayleigh occupied the presidential chair, and there was an attendance of 1,777 persons. To signalise the event, the British Association instituted in McGill University a prize medal for work in applied science, the obverse of which, it is of interest just now to chronicle, bears the head of James Watt; the reverse has a wreath of maple and rose leaves. With this precedent in mind, South Africa may possibly desire to receive a similar record of the present visit.

In 1897 the Association visited Toronto, having Sir John Evans as President. Here the attendance reached 1,362.

The idea of the British Association as an amalgamation of scientific interests is clearly set forth in a letter addressed by Sir David Brewster in 1831 to Mr. John Phillips, F.G.S., the Secretary of the Philosophical Society of York, and although this has been commented on in all its bearings before now, it will bear recapitulation, more especially at a moment when the Association is breaking fresh ground and is grasping the hands of new friends.

Subjoined is the letter referred to:—

Allerby, by Melrose, February 23rd, 1831.

"Dear Sir,—I have taken the liberty of writing to you on a subject of considerable importance. It is proposed to

Photo by Maull & Fox.]

PROF. A. R. FORSYTH, F.R.S.

PROF. ANDREW RUSSELL FORSYTH, Sadlerian Professor of Pure Mathematics in the University of Cambridge, is President of Section A, Mathematical and Physical Science. He is the author of many treatises on subjects of mathematical analysis, and is a Royal Medallist of the Royal Society.

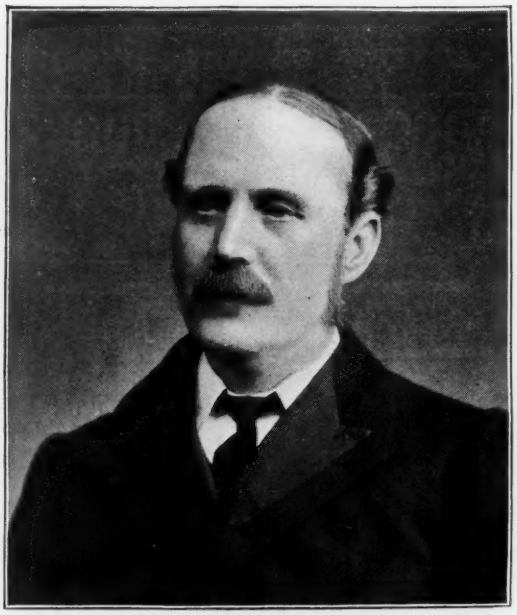

Photo by Maull & Fox.]

MR. G. T. BEILBY, F.C.S.

MR. GEORGE THOMAS BEILBY, of Glasgow, President of Section B, Chemistry, is a past president of the Society of Chemical Industry, and an authority on chemistry as applied to the arts of life. He has specially studied the industrial aspects of fuel supplies, and is the compiler of a "Review of the Coal Consumption of the United Kingdom." Among his recent papers are: "The Position of the Cyanide Industry"; "The Intensification of Chemical Action by the Emanations from Gold and Platinum"; and "Phosphorescence caused by the Beta and Gamma Rays of Radium."

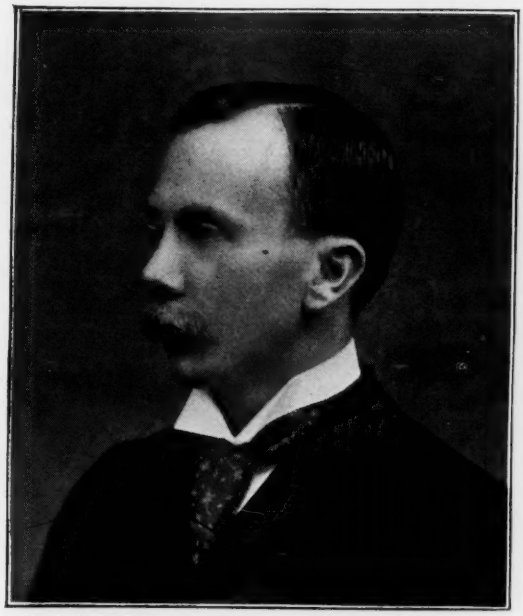

Photo by Maull & Fox.]

PROF. H. A. MIERS, F.R.S.

PROF. HENRY ALEXANDER MIERS, Waynflete Professor of Mineralogy in the University of Oxford, is President of Section C, Geology. Formerly he was an Assistant in the Department of Minerals, British Museum (Natural History). He is the author of many memoirs in mineralogy and crystallography.

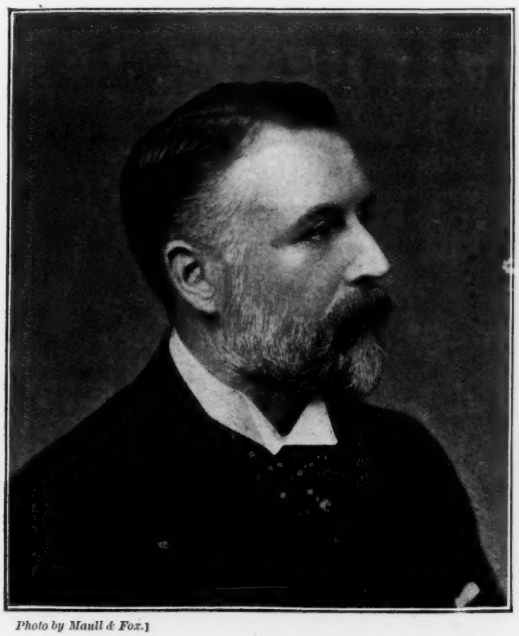

Photo by Maull & Fox.]

MR. G. A. BOULENGER, F.R.S.

MR. GEORGE ALBERT BOULENGER, of the Department of Zoology, British Museum (Natural History), is President of Section D, Zoology. He is the author of reference works on Batrachia, Lizards, Chelonians, and Crocodiles, and is an authority on the fishes of Africa.

establish a British Association of Men of Science, similar to that which has existed for eight years in Germany and which is now patronised by the most powerful sovereigns in that part of Europe. The arrangements for the first meeting are in progress, and it is contemplated that it shall be held in York, as the most central city of the three kingdoms. My object in writing to you at present is to beg that you would ascertain if York will furnish the accommodation necessary for so large a meeting, which might perhaps consist of 100 individuals; if the Philosophical Society would enter zealously into the plan, and if the Mayor and influential persons in the town and in the vicinity would be likely to promote its objects. The principal objects of the Society would be to make the cultivators of science acquainted with each other; to stimulate one another to new exertions; to bring the objects of science before the public eye, and to take measures for advancing its interests and accelerating their progress. The Society would possess no fund, make no collections, hold no property, the expense of each anniversary meeting being defrayed by the members who are present.

"As these few observations will enable you to form a general opinion of the object in view, I shall only add that the time of meeting which is likely to be most convenient would be about the 18th or 25th of July.

"I am, dear Sir,

"Ever most truly yours,

"D. BREWSTER."

"J. Phillips, Esq."

The Philosophical Society and the civic authorities of York viewed the proposition with every mark of favour, and it was arranged that the inaugural meeting of the Association should be held in the Yorkshire Museum on Tuesday, September 27, 1831, the first President to be Viscount Milton, F.R.S. At this gathering the admirable Statement of Objects, drawn in almost identical terms with those which appear at the head of this notice, was unanimously adopted as the initial propaganda of the Association, and thus it remains to-day.

The second President of the Association was the Rev. William Buckland, D.D., F.R.S., Professor of Geology and Mineralogy in the University of Oxford, and the meeting took place in that city. It has been chronicled by one who was present that Buckland was the life of the whole assembly. Curiously enough no numerical record seems to have been kept of the attendance of members. The third meeting was held under the patronage of the sister University, Cambridge, the Rev. Adam Sedgwick, F.R.S., presiding, after which Edinburgh and Dublin had their turn and the Association was then fairly launched.

It would be tedious to detail the successive doings of the Association year by year, or relate how it has gradually grown in power and usefulness. Annually some suitable provincial town is chosen as the venue, and one visit does not preclude another. But the Association never meets in London. The Presidents have always been selected with a real regard to the position and authority they hold in the branch or branches of science they represent, and it is to this jealous care that much of the repute the Association now enjoys is due. Then, too, their addresses in themselves furnish an epitome of the progress of science. Nor should the loyal services of the General Officers be overlooked; some of them, indeed, will be seen to have directed the helm of affairs for long periods. Incidentally it may be mentioned that His Royal Highness the Prince Consort was President of the meeting held at Aberdeen in 1859.

The work of the British Association is carried on in eleven Sections, which represent, as it were, the cycle

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of the sciences. Each has its own president for the time being, and the "Transactions" of these Sections, together with the "Reports on the State of Science" and Presidential addresses constitute the contents of the invaluable series of volumes which have been issued without break since the year 1833, the first date of publication.

As at present constituted the Sections comprise the following divisions:—A, Mathematical and Physical Science; B, Chemistry; C, Geology; D, Zoology; E, Geography; F, Economic Science and Statistics; G, Engineering; H, Anthropology; I, Physiology; K, Botany; L, Educational Science. The employment of alphabetical letters to distinguish the Sections was introduced in 1835.

The discussions on scientific questions which annually take place in the Sectional Committees were regarded from the first as calculated to foster and strengthen the spirit in which the Association was conceived, as well as exemplifying its principles. But the enormous extension in the boundaries of science which the past fifty years has witnessed has naturally brought in its wake an enlarged platform for the stream of criticism and comment. This development has, indeed, suggested to some of the veteran habitués of the meetings that there is now, perhaps, an over-expression of opinion, and they recall with lingering regret the notable assemblages of a brilliant, if small, band of scientific expositors, whose personality was the focus of the gatherings; their flights into the whirlpools and rapids of argument or conjecture, a keen and satisfying experience. But without "talk" the modern Congress would die of inanition; it is, in short, a safety-valve that had best be left untouched.

Since 1867 an interesting and popular feature of the meetings has been the delivery of a lecture on some particular scientific subject, designed especially for an audience of working-men. The first of the series was given by John Tyndall, on "Matter and Force," and at last year's Cambridge gathering there was a discourse on "The Form of Mountains."

In 1884 a "Corresponding Societies Committee" was instituted with the view of encouraging the affiliation of local Scientific Societies in order that they might be formally in correspondence with the Association, and thus assist in promoting its objects. At present 72 local bodies constitute Corresponding Societies, but it is hoped that this relatively small number will steadily increase.

No outline of progress should, however, omit to mention the money grants which the Association has bestowed from its necessarily limited funds in furtherance of scientific purposes. The grand total of such sums allotted since the year 1834 amounts to no less than £68,300.

Our survey, brief though it is, will, perhaps, serve to indicate the plan and general scope of the organisation, as well as the fruitfulness of its career.

It stands to-day, as in the past, moved by no advertisements or trumpeting fanfares, or idea of self-aggrandisement, essentially a silent force working with definite aims and understanding for the advancement of the several branches of scientific thought and knowledge. Actuated thus, the Association transplants its standard to South Africa, a step bold and far-seeing enough to command a common approval, as also it enlists our brightest hopes for a successful and prosperous gathering.

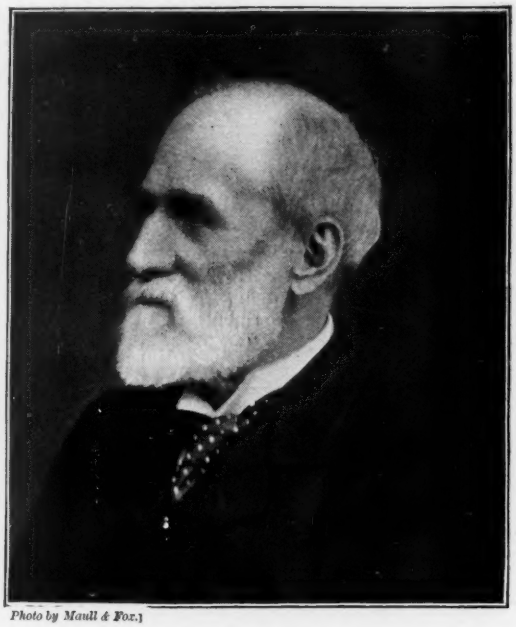

Photo by Maull & Fox.]

SIR W. J. L. WHARTON, K.C.B., F.R.S.

REAR-ADMIRAL SIR JAMES LLOYD WHARTON, till lately Hydrographer of the Navy, is President of Section E, Geography. He has had charge of Surveys in various parts of the world. Author of a work on "Hydrographical Surveying." In 1874 he took part in observations on the Transit of Venus.

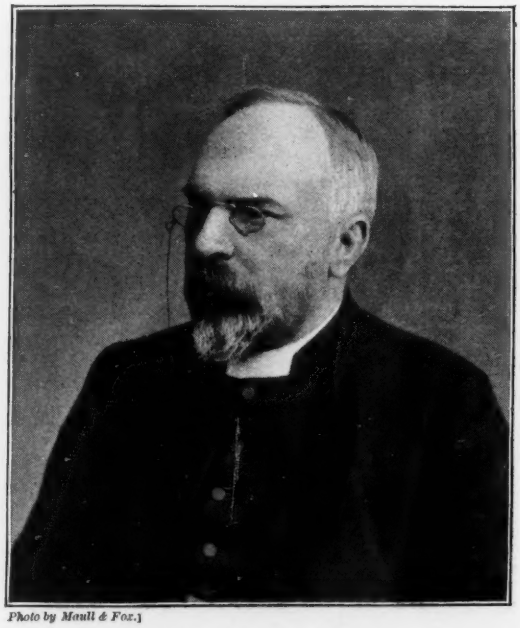

Photo by Maull & Fox.]

REV. W. CUNNINGHAM, D.D.

THE REV. DR. CUNNINGHAM is President of Section F, Economic Science and Statistics. Fellow of Trinity College, and Lady Margaret Preacher. Sometime Lecturer in Economic History, Harvard University. Author of "Growth of English Industry and Commerce in Modern Times," 1904 (3rd ed.); "The Use and Abuse of Money"; "Gospel of Work"; "Ancient Times" "The Path towards Knowledge."

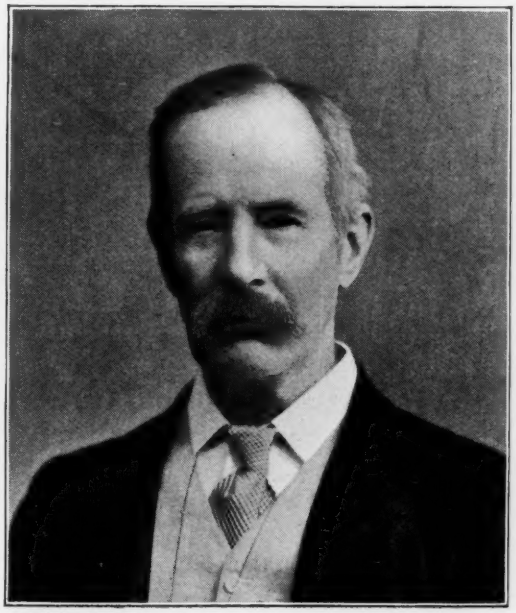

Photo by Maull & Fox.]

SIR C. SCOTT-MONCRIEFF, G.C.S.I.

COLONEL SIR C. SCOTT-MONCRIEFF, late Bengal Engineers (medal Indian Mutiny), is President of Section G, Engineering. He has been respectively Under-Secretary, Public Works Office, Egypt, and Under-Secretary for Scotland. In the former capacity, he carried out important work in connection with Nile barrage. Author of "Irrigation in Southern Europe."

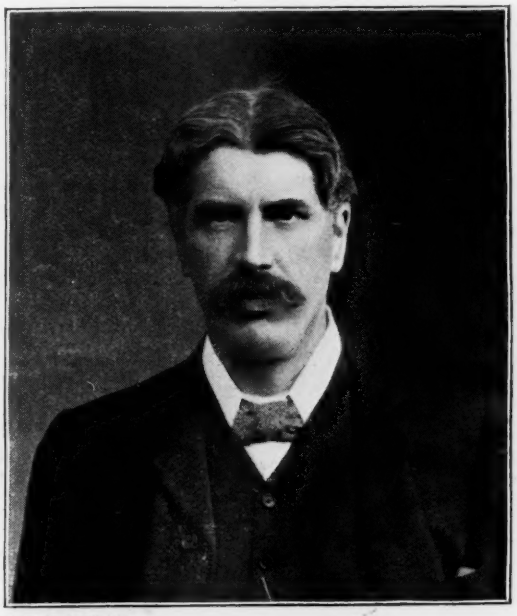

Photo by Maull & Fox.]

DR. A. C. HADDON, F.R.S.

DR. ALFRED CORT HADDON, University Lecturer in Ethnology in the University of Cambridge, formerly Professor of Zoology in the Royal College Science, Dublin, is President of Section H, Anthropology. In 1888, he went to Torres Strait to investigate the structure of the coral reefs, and the fauna, and also studied the ethnography of the Islanders.

Programme of the Meeting.

On Saturday, July 22, the *Durham Castle* and *Kildonan Castle* sail for South Africa, carrying, respectively, a complement of 108 and 45 members of the Association. On Saturday, July 29, the *Saxon* sails with 139 members, who constitute the Official party, and are the guests of the South African Colonies. With earlier departures, the total number proceeding to the meeting will fall little short of 400.

CAPE TOWN.—The *Saxon* arrives at Cape Town (early morning) on Tuesday, August 15, and the work of the Association commences forthwith. A meeting of the Council will take place at noon, and the 11 Sectional Committees and the General Committee will also foregather.

The President's Address to the Association will be delivered (in part) at the inaugural meeting to be held in the evening.

In this, Professor Darwin proposes to discuss the general principles involved in theories of evolution, with special reference to the world of inanimate matter. He will illustrate the subject by means of various theories of the intimate constitution of matter and of cosmical evolution.

August 16.—Presidential Addresses to Section A, Mathematics and Physics; Section D, Zoology; Section E, Geography; Section F, Economic Science and Statistics; Section H, Anthropology; and Section L, Educational Science.

In the afternoon a garden party will be given by His Excellency the Governor (Sir Walter F. Hely-Hutchinson); in the evening there will be a reception by the Mayor of Cape Town.

August 17.—Sectional Meetings.

In the evening Prof. E. B. Poulton, F.R.S., delivers a lecture on "W. J. Burchell's Discoveries in South Africa."

August 18.—Sectional Meetings.

In the evening Mr. C. V. Boys, F.R.S., delivers a lecture on "Some Surface Actions of Fluids." Following this a conversazione will be given by the combined scientific societies of Cape Town, at the South African Museum.

In the afternoon, Sir David Gill, K.C.B., F.R.S., will give a reception at the Royal Observatory.

The "Saxon" leaves for Durban (evening).

August 19.—Whole day excursions to, among other places of interest: Table Mountain; De Beers Explosive Works; Hout Bay; Admiralty Works, Simon's Town; Marine Station, St. James's.

The "Durham Castle" leaves for Durban direct, arriving in the forenoon of Tuesday, August 22.

DURBAN.—*August 22.*—A lecture will be delivered in the Town Hall in the evening by Mr. Douglas Freshfield, F.R.G.S., on "Mountains: the Highest Himalaya."

In the afternoon a garden party at Sir Benjamin Greenacre's.

August 23.—Visit to Botanic Gardens; trip (full day) to Umkomaas; circular trip round the Bay; inspection of Girls' Model Primary School; Mount Edgecombe (Sugar Estate); Parade of Cadets.

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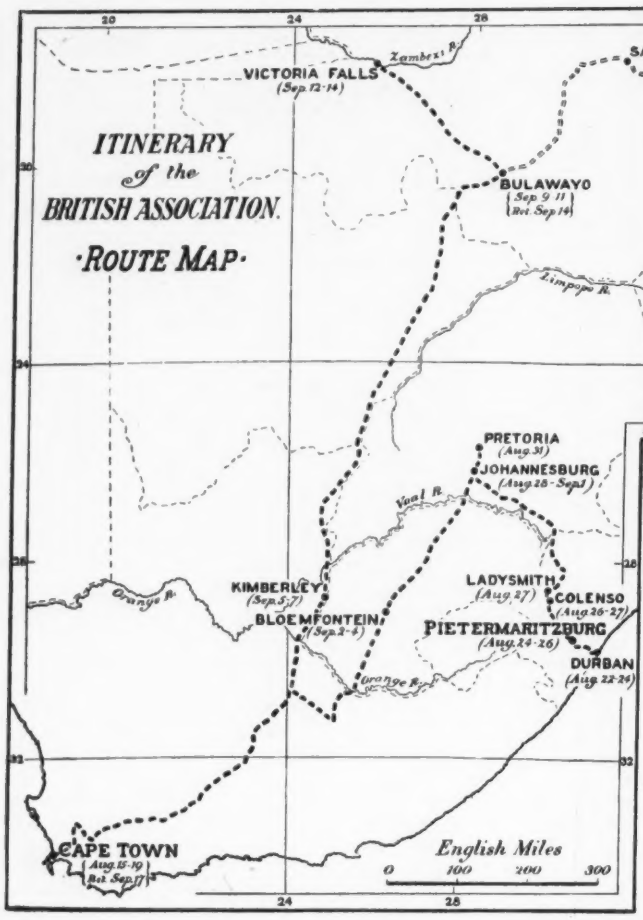


TABLE OF DISTANCES

	Miles.
Southampton to Cape Town	5,978
Cape Town to Johannesburg	1,013
Cape Town to Bloemfontein	750
Cape Town to Kimberley	647
Cape Town to Bulawayo	1,362
Bulawayo to Victoria Falls	275

PIETERMARITZBURG.—*August 24.*—Leave Durban for Pietermaritzburg, by special trains (morning). In the evening, Colonel David Bruce, C.B., F.R.S., will deliver a lecture on "Sleeping Sickness."

In the afternoon, a garden party.

August 25.—Visits to the Museum, Educational Institutions, and Public Buildings generally.

Excursion to Native Location, Henley, with Kafir dance; Government Experimental Farm, Codara; Government Laboratory, Allerton; Town Bush Valley Nurseries.

August 26.—Leave Pietermaritzburg by special trains for a visit to Colenso; sleep in the special trains; leave for Ladysmith *August 27* (Sunday) and visit the town; depart same day for Johannesburg.

JOHANNESBURG.—*August 28.*—In the evening a lecture will be delivered by Prof. W. E. Ayrton, F.R.S., on "Distribution of Power."

August 29.—Sectional Meetings. Presidential Addresses to Section B, Chemistry; Section C, Geology; Section G, Engineering; Section I, Physiology; and Section K, Botany.—A Report by Mr. G. W. Lamplugh, F.R.S., on the "Geology of the Victoria Falls," will take the form of an afternoon address to Section C.

In the afternoon a garden party will be given by His Excellency the High Commissioner for South Africa (the Earl of Selborne, G.C.M.G.); in the evening, a reception by the Mayor and Town Council of Johannesburg.

August 30.—Sectional Meetings (morning); visit to Mines (afternoon).

In the evening Prof. G. H. Darwin will deliver the second portion of the Presidential Address in St. Mary's Hall.

PRETORIA.—*August 31.*—Visit to Pretoria.

In the evening a lecture will be delivered by Mr. A. E. Shipley, F.R.S., on "Fly-borne Diseases, Malaria, &c."

A garden party will be given by His Excellency the Lieutenant-Governor (Sir Arthur Lawley, K.C.M.G.). Visits will be paid to the Museum and Zoological Gardens, and other places of interest. A luncheon will be given by the Mayor and Town Council of Pretoria. Excursions can be made to the Dynamite Factory, Modderfontein, and the Premier Diamond Mine.

The President and most of the members will sleep at Pretoria, but the Sectional officers return to Johannesburg in the evening by special train.

JOHANNESBURG.—*August 31.*—In the evening a lecture will be delivered by Prof. J. O. Arnold on "Steel as an Igneous Rock."

September 1.—Sectional Meetings (morning); General Committee (afternoon).

In the afternoon there will be a Kafir dance at the Wanderers' Club. During the Johannesburg visit various excursions will be made, and visits of inspection paid to Public Buildings and to the Government Experimental Farm, Potchefstroom. There will also be a cross-country trip for a limited number to Mafeking.

BLOEMFONTEIN.—*September 2.*—A lecture will be delivered in the evening by Mr. A. R. Hinks, on "The Milky Way and the Clouds of Magellan."

A public welcome will be extended to the Association by the Mayor and Town Council of Bloemfontein, and there will be a reception at Government House.

September 3 (Sunday).—Special train to Modderpoort, stopping at Sannah's Post; lunch on board the train, provided by the hospitality of the town. A trek to Kimberley will be arranged for a limited number, touching Driefontein and Paardeberg, and camping in General Cronje's old laager.

September 4.—Leave Bloemfontein by special trains for Kimberley.

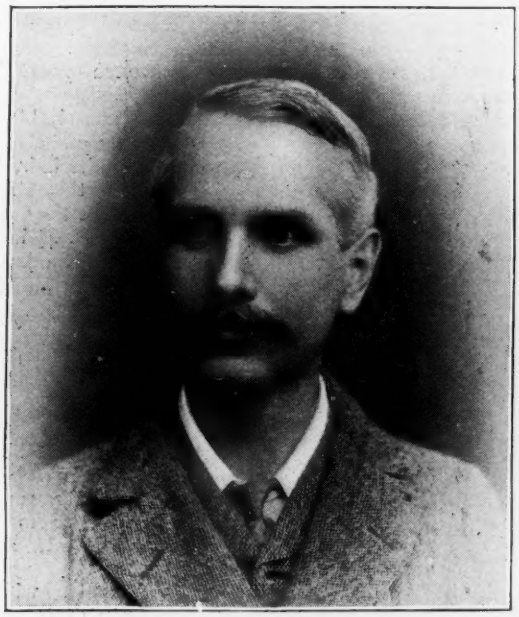
KIMBERLEY.—*September 5.*—In the evening a lecture will be delivered by Sir William Crookes, F.R.S., on "Diamonds."

Underground visits to Mines (in parties) will be made. There will be a garden party at the Public Gardens.

Photo by Maull & Fox.]

COL. BRUCE, C.B., F.R.S.

COL. BRUCE, R.A.M.C., President of Section I, Physiology, now resident in London, was formerly quartered at Pietermaritzburg. An authority in various branches of Pathological enquiry, he discovered (1887) the micro-organism of Malta Fever (*Micro-coccus Melitensis*). In Zululand, under official auspices, he studied the devastating Tsetse Fly disease, or Nagana. In Uganda, he recently investigated with striking success the causation of the dreaded malady Sleeping Sickness, and denoted the actual carrier of the infective organism to be a species of Tsetse Fly.



MR. H. W. T. WAGER, F.R.S.

MR. HAROLD W. T. WAGER, H.M. Inspector of Schools (Secondary Branch), President of Section K, Botany, was formerly Lecturer on Botany in Yorkshire College, Leeds. He is the author of numerous botanical memoirs, among these "The Sexuality of the Fungi"; "On the Phosphorus containing-Elements in Yeast."

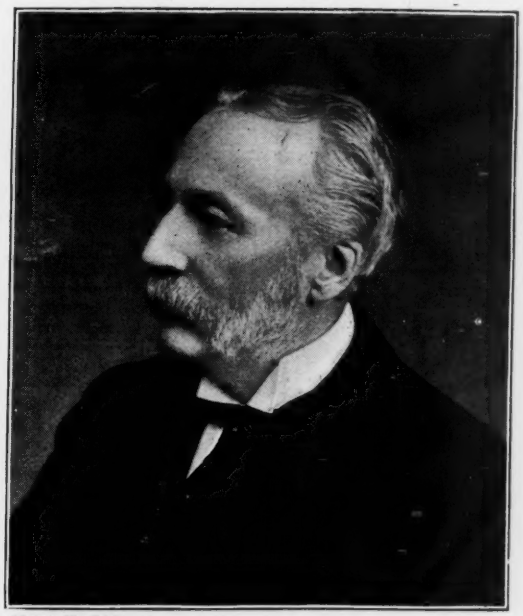


Photo by Maull & Fox.]

SIR R. C. JEBB, M.P., O.M.

SIR RICHARD CLAVERHOUSE JEBB, Regius Professor of Greek in the University of Cambridge, is President of Section L, Educational Science. A distinguished member of the British Academy, he was recently the recipient of the Order of Merit. He represents Cambridge University in Parliament.

September 6.—In the evening a lecture will be delivered by Prof. J. Bonsall Porter, of Montreal, on "The Bearing of Engineering on Mining."

In the morning the whole body of visitors will entrain at Kimberley for Beaconsfield, thence to De Beers Sidings, and will proceed by rail to Du Toit's Pan and Wesselton Mines. Trips will be made to Kenilworth, Pulsator, and Alexandersfontein.

September 7-8.—Leave Kimberley *en route* for Bulawayo (Official party).

BULAWAYO.—*September 9.*—In the evening a lecture will be delivered by Mr. Randall MacIver on the "Zimbabwe."

In the course of the morning and afternoon the Public Buildings, Memorials, and Museum will be inspected; in the evening a conversazione will take place in the Drill Hall.

September 10 (Sunday).—Leave for Matopos by train; travel by coach through the Matopos to the World's View. Inspect Rhodes Park, the site of the grave of Mr. Cecil Rhodes, Shangani Memorial, and the Khami Ruins, and return to Bulawayo.

September 11.—Official party leaves for the Victoria Falls.

September 12.—Arrive at Victoria Falls; visit the Palm Grove, Rain Forest, Zambezi Bridge, &c.

September 13.—Leave Victoria Falls (morning) for Bulawayo.

September 14.—Official party arrives at Bulawayo (early morning), Garden party in South Park (afternoon). Official party leaves for Cape Town (evening), arriving Sunday, September 17 (afternoon).

September 20.—The Official party, homeward bound, leaves for England, arriving at Southampton on Saturday, October 7.

Members who are returning to England by the Beira route leave the Victoria Falls, September 14, and embark on the *Durham Castle* on Sunday, September 17. The ports of call are: Mozambique, Zanzibar, Mombasi (Kilindini), Port Said, Marseilles, and Southampton, the last-named being reached on October 20.

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THE BRITISH ASSOCIATION, 1905.

President.

PROFESSOR G. H. DARWIN, M.A., LL.D., Ph.D., F.R.S.

Vice-Presidents.

HIS EXCELLENCY THE RIGHT HON. THE EARL OF SELBORNE, G.C.M.G., High Commissioner for South Africa.
THE RIGHT HON. LORD MILNER, G.C.B., G.C.M.G., late High Commissioner for South Africa.
THE HON. SIR WALTER F. HELY-HUTCHINSON, G.C.M.G., Governor of Cape Colony.
COLONEL SIR HENRY E. McCALLUM, G.C.M.G., R.E., Governor of Natal.
CAPTAIN THE HON. SIR ARTHUR LAWLEY, K.C.M.G., Lieutenant-Governor, Transvaal.
MAJOR SIR H. J. GOOLD-ADAMS, K.C.M.G., Lieutenant-Governor, Orange River Colony.
SIR W. H. MILTON, K.C.M.G., Administrator of Southern Rhodesia.
SIR DAVID GILL, K.C.B., LL.D., F.R.S., H.M. Astronomer, Cape Colony.
SIR CHARLES H. T. METCALFE, Bart., M.A.
THEODORE REUNERT, M.Inst.C.E.
THE MAYOR OF CAPE TOWN.
THE MAYOR OF JOHANNESBURG.
THE PRESIDENT, PHILOSOPHICAL SOCIETY OF SOUTH AFRICA.
THE MAYOR OF DURBAN. | THE MAYOR OF MARITZBURG.
THE MAYOR OF BLOEMFONTEIN. | THE MAYOR OF PRETORIA.
THE MAYOR OF KIMBERLEY. | THE MAYOR OF BULAWAYO.

General Treasurer.

PROFESSOR JOHN PERRY, D.Sc., F.R.S.

General Secretaries.

MAJOR P. A. MACMAHON, R.A., D.Sc., F.R.S.
PROFESSOR W. A. HERDMAN, D.Sc., F.R.S.

Central Organising Committee for South Africa.

SIR DAVID GILL, K.C.B., F.R.S., *Chairman.*
J. D. F. GILCHRIST, M.A., PH.D., B.Sc., *Secretary.*

A. SILVA WHITE, *Assistant Secretary.*
H. C. STEWARDSON, *Chief Clerk* and *Assistant Treasurer.*

The Races of South Africa.

THREE main races may be distinguished in the south of the African continent: the Bushmen, the Hottentots, and the Bantu-speaking peoples. None of these possess any written records, and the only materials for their history consist in native traditions and folk-lore, and the reports of travellers of the past hundred years or so. From these sources of information an attempt has been made to trace the origins and early relationships of the indigenous tribes, but much work remains to be done before any definite ethnological grouping can be verified.

Bushmen.—When the early travellers landed at the Cape, the first peoples with whom they came in contact were the San and Khoikhoi, better known respectively as the Bushmen and the Hottentots. The former were the aboriginal inhabitants of the south of the continent, and there is evidence to show that before the era of the Bantu migrations from the north-east, they occupied the land south of the equatorial lakes.

The Bushmen were a hunting people, living on the abundant game, owning no lords, and possessing no political organisation. But at the very beginnings of South African history we see their doom foreshadowed, for this aboriginal hunting folk could make no stand against the steady migration of the Bantu-speaking tribes pouring down from the north-east, and in the 17th century they were being gradually driven out of the more fertile lands into the south and west. The settlers proved an even more dangerous enemy on the south, for by the Europeans these aboriginal owners of the land were treated, not as men, but as wild animals, to be exterminated. The extermination would have proceeded more rapidly had not the Bushmen been possessed of one admirable means of defence. Their only weapons were bows and arrows; the bows usually very poor and the arrows often merely made of reeds, but the piece of bone, flint, or iron forming the tip was dipped in deadly poison, which rendered a slight wound mortal; and the colonists learnt to mingle fear with their contempt. Sentries were practically useless against these wary attackers, and one Bushman could keep a whole European settlement in a state of constant alarm. Owing to his diminutive size and his extraordinary ability for taking cover, he could make himself almost invisible, and the skill and cunning of the born hunter were preternaturally sharpened when he himself became the quarry. Much of the disafforesting of South Africa was due to the fear of the Bushmen, for the colonists cleared all the bush near their dwellings to guard against stealthy attacks.

Between the dense masses of Bantu peoples sweeping down from the north-east, and the ever-encroaching colonists on the south, the Bushmen were forced to retreat, and they sought refuge in the fastnesses of the mountains and in the deserts, where they are still to be met with, still living in the primitive method, by hunting, still using the same rude weapons, the bow and arrow; still in the stone age of culture from which our ancestors emerged some few thousands of years ago, and still making fire by friction, like prehistoric man and savages all over the world.

In physical characteristics they differ considerably from their Bantu neighbours. The skin colour is naturally a fawn yellow, and even when obscured by layers of grease and dirt, it is distinctly lighter than the prevailing tint in the Dark Continent. The black hair has earned by its method of growth the name of "pepper-corns," for though it is distributed normally and evenly over the surface of the head, the little short black tufts cling together in tight spirals, leaving bare spaces between, and suggesting a sprinkling of pepper-corns over the scalp. The average stature is 1.529m. (5 ft. 0¼ in.). The head is low and moderately narrow, the face straight, without projecting jaws, the nose extremely low and broad.

Hottentots.—While the Bushmen were nomadic hunters, the Hottentots were nomadic herdsmen, and they are generally assumed to represent an early blend in another part of the continent of Bushmen and Bantu stocks. In skin colour, in the nature of the hair, in certain physical characteristics and in speech they show considerable affinities with the Bushmen, but they are distinguished by a taller stature, 1.639m. (5 ft. 4½ in.), a narrower head, and pronounced projection of the jaws.

They formerly extended from Namaqualand on the west to beyond the Limpopo, and traces of their occupation are recognised in the heaps of stones or cairns which mark the graves of their warriors. The true Hottentots are now mainly confined to Namaqualand on the west, but tribal groups of the Korannas (Koraqua) of the middle and upper Orange and Vaal rivers, and Hottentot-Bantu or Hottentot-Boer half-breeds, such as the Griquas of Griqualand E. and the Gonaquas, are relics of this once powerful race. Their extinction is due to many causes. Bantu invasions on the north-east, and the encroachment of the colonists on the south, deprived them of the more fertile lands, which want of organisation prevented them from protecting. Like the Dinka of the Upper Nile, and the Todas of the Nilghiris, they have a passionate devotion for their cattle, and it was on account of their herds that they first came in conflict with the Dutch settlers, whose farms threatened their pasturelands. As these were

gradually occupied by the stronger races, the Hottentots could no longer support their herds, their only means of existence, and many were reduced to slavery on the farms of the invaders, where their cleverness in handling cattle made them valuable as drivers of bullock waggons. Their light attachment to the soil, due to their inherent love of wandering, made their displacement the less difficult, and the national vice of dacha-smoking to excess, together with the vice of spirit drinking, acquired from the settler, accelerated their degradation.

Koranna.—The Koranna occupied the Middle Orange in the 17th century, but they were always a restless people, whom nothing would bind to the soil. One section of them went up the Vaal and formed an independent kingdom round the town of Mamusa on the Harts river, where they still keep up many of the national customs and speak a corrupt form of the Hottentot language; but owing to their long intercourse with the Kafir tribes, they have developed the physical characters of the latter, and cannot be regarded as pure Hottentots.

Griqua.—The Griqua are Boer-Hottentot half-breeds, whose original home was to the north of the river Olifant. They were forced to retreat before the colonists and founded a republic at Rietfontein. Discords soon led to disruption. One section, under Adam Kok, founded Philippolis and later on Kokstadt in Griqualand East, and another section, under Andries Waterboer, founded Griqua Town in Griqualand West.

Bantu.—In Natal we find ourselves in the midst of a typical Bantu people, the Zulu-Xosa, or Zulu-Kafirs, from whose language the group-name Bantu (people) has been chosen as a general term to include all the African races of Bantu speech. This artificial grouping conceals a heterogeneous mass, containing at least six distinct elements, true Negro, Negrillo, Bushman, Hottentot, Hamite, and Semite, which are blended together in different proportions, producing a wide diversity in physical type.

The chief characteristics of the main Bantu groups are a fairly tall stature, a skin colour of varying shades of red-brown, a high and narrow head, a broad nose, and thick but not everted lips.

It seems probable that the Bantu type is mainly due to a blending of the true Negro, of the type found to-day in greatest purity in West Africa and the Sudan, with a Hamitic stock, and that the centre of the dispersion was somewhere in the neighbourhood of British East Africa. From their dual ancestry the Bantu inherited the aptitude for agriculture, and for cattle-rearing, and, provided thus with an ample supply of food, living in a magnificently fertile area, possessing also a political organisation, which developed into tribal grouping, they flourished, and increased and multiplied to such an extent that now their teeming millions swarm over almost the whole of South Africa.

In their earlier wanderings they must have mixed to a considerable extent with the aboriginal inhabitants, and we find distinctly Hottentot features among the Bechuana, who are regarded on this and other grounds as being among the earliest immigrants. The later waves preserved a purer type, such as the Zulu-Xosa, who are comparatively recent arrivals in their present territory, though a long period of contact with the aborigines is shown by the adoption of three clicks into the language.

Xosa.—At one time the Xosa spread far to the south, and the first conflict with the whites took place in the Swellendam district in the middle of the 18th century. Later on the boundary was fixed at the Great Fish river, but the rapidly increasing people had spread by 1800 as far as Mossel Bay. Then force was brought to bear on them, and troops were called out, but the general retreat did not take place until 1835. External restrictions produced internal shiftings and disturbances and general disorganisation, leading to a loss of independence for all the clans.

Zulus.—The history of the Zulus, the northern branch of the Zulu-Xosa, is well known since the time when they sprang into notoriety under the famous Chaka, the terror of whose name was carried for hundreds of miles in every direction by tribes which he had put to flight. Streams of disorganised people fled before him, and some of these, encountering weaker tribes in their flight, attacked them and took possession of their lands: thus the disorganisation spread. The Fecane, or Fingu, Xezibe, Baca, and Amahlubi fled to the south, and the Fecane, after being slaves to the conquerors, were freed in 1835, and formed the Fingu location near Port Elizabeth.

Matabele.—The Matabele, "the men who disappear," so called from their immense bucklers, having fled across the Drakensberg, gathered together under Umsilikatsi and poured in a vast army across Bechuanaland, conquering the sedentary tribes, and augmenting their numbers by captives and fugitives. They were defeated and almost annihilated by the Boers, but this catastrophe was only a brief check in their victorious career, which culminated in the defeat of the Mashona and the occupation of Mashonaland, Rhodesia.

Mashona and *Makalaka.*—The Mashona and Makalaka were probably among the earlier waves of Bantu migration. Tradition ascribes to the Makalaka a powerful kingdom, which lasted for 300 years, between the Limpopo and the Zambezi, and the Mashona lived to the north of them as far as the Umfuli river. They were powerless before the warlike Matabele, and were either reduced to subjection or sought refuge in flight.

Barotse and *Makololo.*—Another powerful kingdom was that of the Barotse, on the middle Zambezi. This was overthrown by the Makololo, under Sebituane, in 1835, but on the death of Sekeletu, the successor of Sebituane, the Barotse revolted, drove out the Makololo, and re-established their empire on a surer footing.

Thus the history of the Bantu peoples is one of continuous movement, of perpetual shiftings, of states formed by the grouping of many tribes under one forceful leader, and the disruption of these states, either by natural disintegration when the central power weakens, or before the attack of some greater or stronger force. The grouping is political rather than racial, and hence it tends to produce a blending rather than a differentiation of type.

The ethnology of a country is always influenced by the environment, and this is notably the case in South Africa. Here is an immense stretch of country, containing few barriers to limit expansion in any direction or to provide security against attack. Hence the racial history has shown streams of people perpetually moving in all directions, producing an infinite fusion of types, a uniformity in diversity, which makes South African ethnology a subject of unusual complexity, needing a great deal of patient unravelling before the affinities of even the main races can be clearly discovered.

XUM

The Diamond Mines of South Africa.

ABOUT forty-eight years ago a child picked up a diamond in the gravels of the Orange River. Experts in Europe were not very ready to believe the news, but others were found, and in 1870 the gem was discovered in the so-called "dry ground"—large patches of a peculiar clayey material well away from any stream course. This was at a spot which is now the noted Dutoits Pan Mine, near Kimberley. During the next year three other diamantiferous patches were detected in this neighbourhood; one, the present Bultfontein Mine, within a short distance to the south; another, the De Beers, about two miles away to the north-west, and the third, the Kimberley, about a mile west of it. They formed low hills or kopjes, rising from a comparatively level basin; the tops of the Kimberley and its neighbour being about 4,000 feet above sea-level, and the others a few hundred feet lower. The country rock is a dark shale, with occasional beds of hard sandstone, belonging to the Karoo series of geologists, which is either a little older than, or contemporary with, the European Trias, and is very different from the diamantiferous material, which was afterwards found to fill large vertical pipes or funnels, descending to an unknown depth. These were nearly oval in form, the area of the largest, Dutoits Pan, being about 41 acres; that of the smallest, the Kimberley, about nine acres. Since then several other diamantiferous patches have been discovered, to which we shall presently refer.

The nature of the material and the origin of the gem have long been geological problems, but the former of them has at length been solved, and the latter is much better understood. The difficulty partly arose from the state of the material. The yellow ground, to use the miners' name for that first dug up, was a rotten clayey stuff in which sundry minerals and rock fragments were scattered. This, they found, passed gradually down—perhaps a hundred feet from the surface—into a dark bluish-green material, which they called "blue ground." Though more coherent than the other, it also was at first ill-suited for microscopic examination, by which, however, the minerals scattered through it, sometimes as fragments, could be determined. The more notable, besides the diamonds, were garnets of one or two kinds, iron oxide, generally titaniferous, a brown mica, named vaalite by Professor Story-Maskelyne, a chrome-augite, enstatite, and olivine, more or less converted into serpentine. Fragments of rock, sedimentary and crystalline, were also present; the former often seeming slightly altered. About one-third of the matrix, or blue ground itself, consisted of very minute fragments of these constituents; about half was serpentine, and the remainder a carbonate of lime, sometimes magnesian.

It was impossible to determine the true nature of this rock, or the origin of the diamond, until the blue ground was hard enough to be cut into slices sufficiently thin for a satisfactory examination with the microscope, and this was not reached until the mines were carried down to some hundreds of feet from the surface. The exact depth cannot be precisely stated, or that of the passage from the "yellow" to the "blue ground," but it was not till about a dozen years ago that really good specimens of the latter reached this country. The Kimberley mines had by that time been carried to a depth of over a thousand feet, and the material brought up was about as hard as an ordinary limestone.* These workings also afforded sections of the rocks pierced by these great pipes or shafts. First they found the dark shales already mentioned, sometimes covered, sometimes cut, by masses of an igneous rock allied to basalt. These occupy the first few hundred feet. Beneath them comes a thick mass of similar rock, an old lava flow, often called melaphyre, resting (in the Kimberley district) on a quartzite or very hard sandstone, which continues, thickly interbanded with the dark shales, till, at a depth of more than five hundred yards from the surface, a floor of very ancient crystalline rock is reached. The rock fragments in the blue ground are similar to these, whether sedimentary or igneous; the shales being sometimes quite unaltered, but sometimes with a "baked" aspect, especially in their outer part. The rock, then, is a breccia, and often bears a rough resemblance to that which fills the volcanic necks on the Fifeshire coast. That the pipes had been driven in some way or other through the surrounding rock was indisputable, but it was for long uncertain whether the material in them was a true breccia, like that just mentioned, or some peculiar kind of igneous rock. The latter view was at first more general, and was not incompatible with the presence of rock fragments. The late Professor Carvill Lewis maintained the material (which he named Kimberlite) to be a peculiar kind of peridotite—a rock composed mainly of olivine, but with a glassy matrix—in which the diamonds and other minerals had formed. But farther examination showed the latter to be in many cases indubitably broken, and the rock is now generally admitted to be a true breccia. It has, however, a volcanic or, perhaps, we should say, an explosive origin since we find no signs of ordinary scoria. After the pipes had been filled, steam or hot water probably continued to be discharged for some time, converting the ferromagnesian minerals into serpentine, producing carbonates, forming a peculiar coating on some of the garnets, and more or less affecting the rock fragments.

This, however, did not settle the question whether the diamonds had originated in the pipes or elsewhere, like the other larger minerals. Professor Carvill Lewis, taking the Kimberlite to be an igneous rock, held the former view. So did some of those who maintained it to be a breccia, for they thought the diamond had been produced by the action of very hot water on the carbonaceous material of the dark Karoo shales. But this hypothesis is beset with insuperable difficulties. The crystals of diamond are not unfrequently broken like the garnets or augites, and when perfect are often in a state of strain. Either would be inexplicable had they been formed in such a material as the breccia. Besides this, small diamonds have been found at the De Beers and the Newlands mine (some forty miles north-west of Kimberley), more or less included in garnets, and in 1897 they were detected in two boulder-like pieces of rock which had been brought to England from the latter mine. One of these, when it was broken, displayed in the largest fragment no fewer than ten diamonds, the biggest—an octahedron—measuring about three-twentieths of an inch from point to point.†

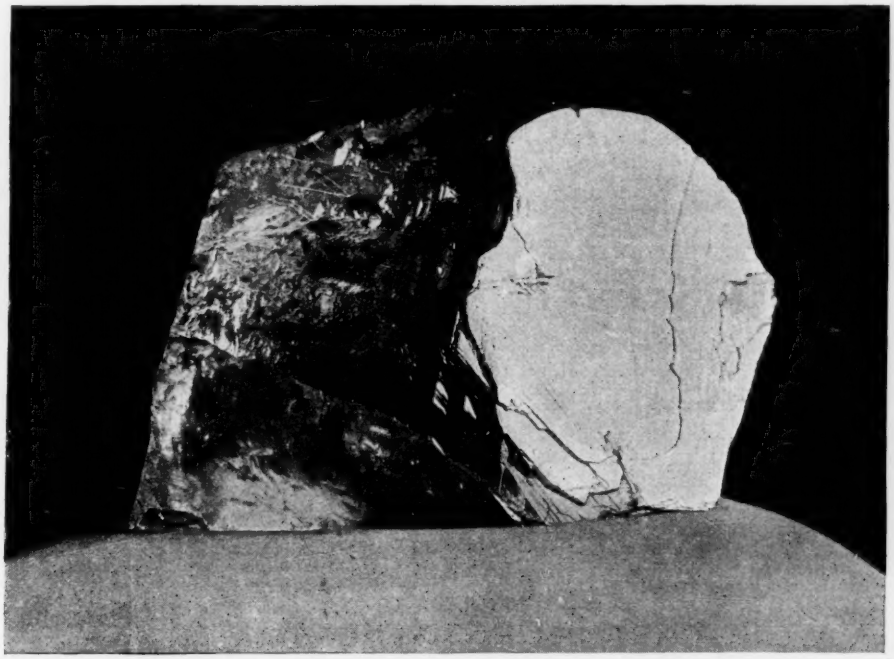
* See Papers in the *Geological Magazine* for 1895, p. 492. Illustrations of the material itself and of its microscopic structure are given in Carvill Lewis' "The Genesis of the Diamond," 1897.

† This fragment was presented by the Directors of the Company to the British Museum. For an account of it, see *Proc. Roy. Soc.*, Vol. LXV., p. 223.

The rock is an eclogite, consisting mainly of red garnets ranging in size from a hemp seed to a pea, and green (chromiferous) augite. This eclogite is now regarded as an igneous rock, and one of those which have crystallized at a considerable depth from the surface. Diamonds, with other forms of crystallized carbon, have been found (though rarely) in meteorites, not only in those of native iron, as at the Cañon Diablo, but in one composed of this metal crystallized with olivine and augite, which fell in 1885 at Nova Urei in Russia. Professor Moissan has made small diamonds by fusing carbon in iron, and cooling the mass so as to cause great pressure at the interior—an experiment which has been repeated by Sir W. Crookes. We must, therefore, conclude that the South African diamonds originated in deep-seated igneous rocks. They have, as yet, been detected only in eclogites, but we may anticipate their occurrence in other crystalline rocks with a lower percentage of silica, and especially in peridotites. These deep-seated masses must have been stripped of their covering and laid bare before the Triassic period began; fragments were detached and rolled into pebbles, forming the conglomerate at the base of the Karoo series, which was duly covered up by the sandstones and shales towards the end of this period. Movements of the earth's crust in Southern Africa caused discharges of lava, in the form of flows and dykes. Then great explosions drilled huge holes through all these, and hurled the shales, quartzite, conglomerate, and the shattered crystalline floor into the air. This mixed stuff, minerals and rock, as it fell back, finally filled the pipes, which, however, continued to be vents for gas, steam, and, perhaps, hot water.

Such is the story of the diamond. There are several other pipes more or less productive, most of which are scattered on a narrow belt about 125 miles in length, which runs, roughly, in a N.N.W. to S.S.E. direction from Newlands on the Hart river in West Griqualand to Faure Smith in the Orange State, parallel, as Dr. Molengraff has pointed out, with the line of the Drakensberg Range. But the group, including the Premier Mine, now famous for the discovery of the Cullinan diamond, must belong to quite another zone of disturbance, for it is about seven leagues east of Pretoria (north of Van der Merve Station). Here the pipes are driven through quartzite and an igneous rock called felsite, so the Karoo shale cannot have helped to make these diamonds.

We must pass over the story of the working of the mines, for it is a long and complicated one, contenting ourselves with stating that, according to De Launay, richer mines produce on an average about 15 grains weight of diamonds to five cubic yards of rock, and that, by 1896, South Africa had produced more than double the quantity of Brazil and India together. A decade earlier its mines in a single year yielded nearly 3,160,000 carats of diamonds.



View of the Cullinan Diamond, showing one of the great cleavage planes. It is resting on another cleavage plane. Approximately natural size.

From a Photograph by Sir William Crookes, F.R.S.

These stones frequently show a very faint resin-yellow tint, but many are perfectly colourless and free from any flaw. The first exceptionally fine one, the Star of South Africa, weighing 83½ carats, was found in 1869. Three years later diggings on the Vaal River produced the Stewart, 228¾ carats. The De Beers Mine came to the front in 1880 with a diamond weighing 428½ carats, which was beaten four years afterwards by one (locality uncertain) weighing 457½ carats.—"On June 30, 1893, the Jagersfontein Mine (the best in the Orange River State) broke the world's record by disclosing a diamond weighing 971¾ carats. It was rather irregular in shape—something like a longish potato—measuring about 3 inches by a little less than 1½ inches." But on January 25 in the present year that was left far behind by the Cullinan diamond, which was found about 18 feet below the surface at the Premier Mine, Transvaal, and of which we give a photograph. It is a stone of excellent water, weighing about 3,024¾ carats.* Yet this monster is itself only a fragment, for four of its bounding faces are cleavage planes, and experts think that the stone, when perfect, may have been quite twice as heavy.

* A carat is 3¼ grains, Troy.

South African Natural History.

Antelopes.—In spite of what we sometimes hear our sporting friends chronicle as to their having shot this or that kind of small "deer" in South Africa, meaning, in reality, some kind of antelope, the fauna of the country is notable on account of the absence of representatives of the deer family (*Cervidæ*), as also of representatives of sheep and goats, and of true wild cattle. The place of the last named is taken by the great and ugly Cape buffalo (*Bos caffer*), an animal entirely different, however, from the water-buffalo with which we are familiar in Italy and other parts of Southern Europe; and the deer of Europe and Asia are replaced in South Africa by a vast assemblage of species of antelopes, many of which are peculiar to the country, although a large percentage belong to genera ranging over the greater part of Africa.

One very characteristic animal is the Cape hartebeest (*Bubalis cama*), a melancholy-looking antelope of the size of a donkey, with a prodigiously long face, twisted lyrate horns, and a foxy-red coat relieved with bluish black. Despite its advantage of being one of the fleetest of South African antelopes, it is now almost killed off in Cape Colony, the Orange River Colony, and the Transvaal, though a few survive in the old Bushman country of Cape Colony and in the North-West Transvaal. In the Kalahari desert big troops still remain. The lovely blesbok and boftebok (*B. albifrons* and *B. pygargus*) were also characteristic South African antelopes, and at one time occurred in tens of thousands; but while the former still exists on several Boer farms in the Orange River Colony and the Transvaal, the latter is represented only by a herd on some flats forming part of the estate of Mr. Vander-Byl near Swellendam, in the south of Cape Colony. Yet another antelope abundant formerly, when it associated with quaggas and ostriches, was the white-tailed gnu, or black wildebeest (*Connochoetes gnu*), which never ranged north of the Vaal River. Before the Boer war it was recorded only on a few farms in the Orange River Colony, and little has been heard since with regard to the species. North of the Orange River its place is taken by the brindled gnu, or blue wildebeest (*C. taurinus*), a species still locally not uncommon. In connection with the hartebeest and gnus may be mentioned the bastard hartebeest, or sassabi (*Damaliscus lunutus*), which surpasses the first in speed, and is an exclusively South African species, now relatively scarce.

Of the smaller South African antelopes, the duiker (*Cephalophus grimmi*), the oribi (*Oribia scoparia*), the grysbok (*Rhaphiceros melanotis*), and the steinbok (*R. campestris*), still survive locally in fair numbers. The beautiful little klipspringer (*Oreotragus saltator*), the so-called South African chamois, is worthy of notice as a mountain species. In the waterbuck (*Colus ellipsiprymnus*), easily recognised by the long and beautifully-ringed horns of the bucks, and the white ellipse on the buttocks, we have a magnificent species now most common in the unhealthy swamps between the Chobi and Zambezi. The vaal roebuck (*Pelea capreolus*) is a much smaller grey animal, with short upright horns to the bucks, inhabiting open, hilly districts south of the Zambezi. Nearly allied is the fox-red reedbuck (*Cervicapra arundinum*), a now scarce species inhabiting river banks. The lovely pala (*Æpyceros melampus*) and the springbok (*Antidorcas euchore*) are inhabitants of the open plains, the latter formerly found in huge herds which made periodical migrations ("trek-bokken") across the country. Herds of considerable size may still be seen in certain districts. The splendid sable antelope (*Hippotragus niger*), which, with its sabre-like horns and dark coat is, perhaps, the handsomest of all antelopes, is not found south of the central Transvaal, and even there is now scarce. Still rarer is its larger cousin the roan antelope (*H. equinus*), though it has wider range. The southern representative of the group was the blaaubok (*H. leucophæus*), of which a few were left in Soete Melk (its headquarters) in 1781, but the last were shot about the year 1800.

The northern karoos of Cape Colony were the favourite haunts of that magnificent South African antelope, the gemsbok, or oryx (*Oryx gazella*), which fears not, if report be true, the onset of the lion, but the species is now very scarce, although a few still linger on the plains south of the lower course of the Orange River. Although the elegant little striped bushbuck (*Tragelaphus scriptus*) is still fairly common in many parts of the country, the lordly kudu (*Strepsiceros capensis*) survives in Cape Colony only in the jungles of the Uitenhage range, where it is protected by British farmers; while the larger eland (*Taurotragus oryx*) has been exterminated from nearly all the territories likely to be visited by the members of the British Association.

Other Big Game.—Among game animals other than antelopes, we may refer to giraffes, of which the Cape form appears to be already exterminated; the hippopotamus, now becoming scarce even in many parts of the Zambezi; the ugly wart-hogs, with their enormous tusks, and their relatives the bush-pigs, easily recognised by their tufted ears. In the horse tribe, the true quagga (*Equus quagga*) of the plains south of the Orange River, and apparently the typical race of the bonte-quagga or Burchell's zebra (*Equus burchelli*), from the north of that river, have already succumbed to the skin-hunters, but other races of the latter species occur further north. The great white rhinoceros, which used to charge the wagons of the pioneer hunters in mistaken apprehension of four-footed enemies, survives only in the shape of a few head specially protected in N.-E. Mashonaland, and perhaps by others near the junction of the White and Black Umvlosi Rivers, and would, indeed, have been practically extinct had it not unexpectedly been discovered on the equator.

General Mammal Fauna.—Of mammals other than big game, and apart from lions and leopards, that are especially characteristic of the country, the following may be mentioned: The spotted hyæna, the aard-wolf or maned jackal, the black-backed jackal, the fennec fox, the hunting dog, and the long-eared fox; various mongoose-like creatures, such as the meer-cat; the great South African baboon; the curious aard-vark or ant-bear, one of the most extraordinary of all mammals; and, among smaller forms, the strange golden moles, so named from the metallic sheen of their fur, and the great strand-mole from the sand-dunes in the neighbourhood of Cape Town. The Cape klip-dass, anglicized by the Colonists into "dassie," is interesting as being the southern representative of an African group with one out-lying Syrian member, as to the real affinities of which naturalists are still somewhat undecided.

Some South African Birds.—To enumerate even a tithe of the birds that deserve mention here would be impossible, but there are a few types, some of which call for comment.

It is worth travelling far to see, for example, such birds as the penguin and the ostrich in a wild state. Both flightless types, we have in the one a good illustration of degeneration, and in the other of the substitution of organs, the wings playing the part of the feet when swimming.

Though the ostrich is no longer to be found in a wild state in Cape Colony, it will probably be met with by those members of the Association who propose to make their way northwards into Rhodesia. Occasionally travelling in groups of from thirty to fifty, and then generally associating with zebras or some of the larger antelopes, this bird more commonly lives in companies of not more than four or five, that is to say, the males appear to live apart, accompanied by their mates.

The actual facts as to the breeding habits of the ostrich do not seem to have been definitely settled. But it would appear, according to Professor Newton, that the females lay their eggs in one nest—a shallow pit scraped out by the feet, the earth so displaced being used to form a wall around the eggs. As soon as ten or twelve eggs have been laid brooding commences. The cock performs this duty by night, his black plumage serving as an admirable protective dress at the time: the females seem to take up this duty in turns by day. Being soberly clad they harmonise with the sandy plains under the glare of the sun. About thirty eggs appear to be laid in the nest, and around it as many more are scattered, which are commonly believed to be used as food by the young. Brooding is believed to be resorted to, by day at least, not so much for the purposes of incubation as to protect the eggs from prowling jackals. It is open to question, however, whether this interpretation is correct, for it is quite possible that by day protection from the sun is absolutely necessary.

Those privileged to visit an ostrich farm may be likely enough to see an old cock bird "roll." This peculiar form of display is adopted preparatory to giving battle to a rival when courting. Suddenly bumping down on his "knees," he will, says Mr. Cronwright Schreiner, "open his wings . . . and then swing them alternately backwards and forwards . . . as if on a pivot. . . . The neck is lowered until the head is on a level with the back, and the head and neck swing from side to side with the wings, the back of the head striking with a loud click against the ribs, first on one side then on the other. The click is produced by the skin of the neck, which then bulges loosely out just under the beak and for some distance downwards, and while "rolling" every feather over the whole body is on end, and the plumes are open like a large fan. At such a time the bird sees very imperfectly, if at all."

The chances of meeting with the secretary bird (*Sergentarius secretarius*) in Cape Colony are by no means so certain as before the war. It is one of the most peculiar of the birds of prey, and one of the most primitive; albeit, in many respects, highly specialised. It is remarkable for the length of its legs and the tuft of long feathers resembling quill pens, which grows out from the sides of the head—hence the name "secretary bird." It feeds largely on venomous snakes, and on this account is supposed to be strictly protected. The prey is killed by means of blows from the wings, followed by vigorous pounding with the powerful feet. There seems, unfortunately, to be a tendency to relax the protection hitherto accorded these birds on the plea that they also eat animals coming under the head of "game." The secretary bird builds a huge nest of sticks, placed on the tops of low bushes. In the interstices of the nests colonies of sparrows breed, quite unmolested by their powerful overlords. In Cape Colony the deserted nests of the secretary birds are now being appropriated by the Stanley crane. The young remain helpless in the nest for a period as long as six months, and for a considerable time after leaving this they are in danger of snapping their long legs, which appear to be very brittle, the body, as large as that of an eagle, being heavy.

Of the other birds of prey we have no space to speak. Many will see eagles and vultures for the first time during the visit.

The Hammer-head, a peculiar and aberrant stork of small size and sombre colour, is one of the curiosities of Cape Colony. Among the Dutch element it is known as the Hammer-kop. This bird, though scarcely larger than a raven, builds an enormous nest, which may be as much as six feet in diameter, and placed either in the fork of a tree or on a rocky ledge. It is made of sticks, roots, grass and rushes, and it is remarkable for the fact that it is roofed over and neatly lined with clay, thereby differing from the nests of all other members of this order.

Hoopoes and Hornbills, if fortune be kind, may, perhaps, be met with. Of the former the most likely to be encountered is a species closely resembling that which occasionally has the temerity to visit the British Islands. The Cape species in question is U. *Africana*. Flocks of the beautiful Wood-hoopoe (*Rhinopomastus*) flitting from bush to bush, resplendent in metallic purple but lacking the crest of its more familiar ally Upupa, may also be looked for. Handsome and useful as these birds are, they are remarkable for their evil smell and the foul condition of their nests. The former appears to be due to a secretion of the oil gland of both old and young, and in this respect the Hoopoes appear to be unique among birds. Is is said that the South American Hoatzin possesses a similar secretive power.

Hornbills are less likely to be seen, and these will only be representatives of the curious ground hornbill, the "Brom-Vogel" of South Africa. This bird is unique among the hornbills for the great length of its legs, an adaptation to a more or less terrestrial life. The Kafirs have a tradition that drought will cease if one of these birds is sunk under water and drowned. Nearly all the hornbills are remarkable for the noise made during flight, which has been likened to that of a steam engine. The "Brom-Vogel" is said to be capable of uttering a note resembling a lion's roar, and audible for a mile.

The hornbills have unique nesting habits, the female retiring to a hollow tree and being walled in by the closing up of the entrance to the hole with dung, some say by the male alone, others say by the efforts of both birds, their own dung being used for this purpose. In the Bornean hornbill, at any rate, this plaster is, how-

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ever, not composed of dung, but of a substance said to resemble vegetable resin, and believed to be composed of a gastric—more probably salivary—secretion combined with the woody fragments of fruit. During her incarceration the female is fed by the male, who, for this purpose, brings up the contents of his gizzard enclosed within the inner lining of this organ.

Parrots and Touracoes may be met with, and so also may the curious Coly or Mouse-bird, and the celebrated Honey-guide (Indicator), which, like many cuckoos, is parasitic.

A word as to Cape pigeons and penguins, which will be the first of the many new birds which will greet the eye of those who are making their maiden trip to South Africa. The Cape pigeon is, though so-called, not a pigeon but a petrel (*Daption capensis*).

The penguin is the species known as the Black-footed Penguin (*Spheniscus demersus*). These representatives of a really remarkable group are still numerous, and after the breeding season may be met with in huge flocks some fifty miles from land. Layard, in his "Birds of South Africa," describes these birds as having the "feet placed so far back as to cause the bird to appear always falling backwards if it attempts to stand on land." It is not easy to understand how such a statement came to be made, for it is well known that penguins of all species walk well, if not hurried. The penguin is an expert diver, using its remarkably transformed wings—which now resemble paddles superficially, hardly distinguishable from the paddles of the porpoises, for example—when under water, after the fashion of birds that fly, the feet being held backwards as in a bird in flight. The prey is caught and swallowed under water. Though it is not generally known, the nostrils of these birds have become obliterated, as in gannets and cormorants, so that breathing is possible only through the mouth.

The Extinct Reptile Fauna of South Africa.

THE biological importance of the wonderful series of remains of extinct South African reptiles which has been gradually brought to light from the rocks of the Karoo system of Cape Colony, Griqualand West, and adjacent territories, hardly needs emphasis. Were it not for the discovery of this reptilian fauna a gap would have remained in that chain of animal evolution which it has been found possible to construct during the last few years. For, as a matter of fact, these marvellous Karoo reptiles actually supply the connecting link between the now widely sundered reptilian and mammalian classes; and without the evidence they afford it may be affirmed that not even the most ingenious and far-seeing of evolutionists could ever have realised how intimate and complete was the connection between these two groups in past times. Needless to say, the closeness of the relationship was by no means fully appreciated at the first outset; and although at an early stage of the investigation Professor Owen was enabled to point to a number of very remarkable mammalian resemblances, both in respect of their bones and their teeth, it was reserved for his successors to fully demonstrate that in these strange African reptiles of a bygone age we have the actual representatives of the ancestral stock from which mammals originated. Possibly even this does not fully emphasize the strength of the case in regard to the interest and importance attaching to these South African reptiles, for since they have representatives in other parts of the world, it might thereby be inferred that these non-African species would have supplied all the information that is really essential in regard to the kinship between mammals and reptiles. As a matter of fact, this is not the case; and there is a considerable probability that Africa, known to have existed as a continental area for a prodigiously long period of time, was really the nursery in which the mammalian type was first evolved from its reptilian ancestry, and that some of the African mammal-like reptiles already known to us are not far removed from being links between the two groups.

Science is indebted for the first discovery of their remains to the late Mr. A. G. Bain, an engineer who was employed in the early part of last century in the construction of military roads on the northern and eastern frontiers of Cape Colony. The actual first discovery appears to have been made by him in 1838, in a spot situated somewhat to the north of Fort Beaufort, near Mildenhalls. A letter from Mr. Bain, dated Fort Beaufort, April 28, 1844, addressed to the Geological Society, records the discovery. Accounts also appeared from time to time in local journals at the Cape, in some of which it is mentioned that Mr. Bain's attention was first attracted by portions of bone projecting from the rock.

After being cleared from matrix, and thus made available, the fossils were described by Professor Owen as a kind of appendix to Mr. Bain's "letter." Mr. Bain, in the latter, referred to the most remarkable of his fossils under the name of "bidentals," in allusion to the single pair of large tusk-like teeth with which the upper jaw is armed, and it was to a skull of this type that Professor Owen gave the name of Dicynodon.

In 1852 Mr. Bain sent another large consignment of reptilian fossils to our Geological Society, which, on the advice of the Professor, were subsequently transferred to the British Museum, together, apparently, with the first collection.

The interest aroused by Professor Owen's description of these remarkable reptiles, as well as by his references to them in lectures delivered before the Royal College of Surgeons, was very great. Among those specially interested was the late Prince Consort, who impressed upon his son, the late Prince Alfred (afterwards Duke of Edinburgh), then about to travel in South Africa, the importance of endeavouring to obtain additional specimens. This advice was not neglected, and on his return from South Africa in 1860, Prince Alfred forwarded Professor Owen two skulls, which were described by the latter in the "Philosophical Transactions" of the Royal Society for 1862. One of the skulls, which belonged to a genus nearly allied to Dicynodon, indicated a new species, and was named *Ptychognathus alfredi*, in honour of the royal collector.

Previous to this, Sir George Grey, then Governor of Cape Colony, had also become interested in these discoveries; and it was to him that Professor Owen was indebted for the first example of a representative of the carnivorous section of these reptiles. Mr. Thomas Bain, son of and successor to the original collector, was likewise an energetic worker, and as time went on important collections of these fossils were brought to-

gether in the museums at Cape Town, Graham's Town, and Albany. Among other energetic collectors, special reference must be made to the late Dr. W. G. Atherstone, who devoted much time to the advancement of our knowledge of South African geology and palæontology, and to Mr. Alfred Brown, of Aliwal North, the possessor of a magnificent collection of fossil reptiles, the result of over forty years' assiduous labour.

Although Professor Owen was the first to describe and name the remains of these extinct reptiles, several other workers have followed him in this line of investigation. A foremost place must be assigned to Professor H. G. Seeley, F.R.S., who made a journey to South Africa for the express purpose of collecting specimens and studying those in the local museums, and who subsequently published the results of his investigations in the "Philosophical Transactions." The relations of these reptiles to mammals formed the leading feature in Professor Seeley's investigations. More recently Dr. R. Broom, now resident in South Africa, has studied the nature of these fossils.

Soon after the first representatives of the reptilian remains were obtained it was recognised that the rocks in which they were entombed formed an extensive series of freshwater deposits, for which the distinctive title of Karoo system was selected; the chief reptile-bearing horizons being those known as the Beaufort and the Stomberg beds. It should be added that in addition to the remains of reptiles, these beds contain ferns of the genus *Glossopteris*, and that freshwater deposits similarly containing *Glossopteris*, and in some cases also Dicynodont reptiles, have likewise been met with in India, Australia, and Argentina. Hence it has been inferred that in early times the so-called "Glossopteris flora," with its associated animals, formed a zone round the world, lying to a great extent in low latitudes.

The next question was to determine the age of the Karoo system and its equivalents in other parts of the world. As the result of much discussion, it is now generally admitted that this corresponds in the main with the Trias, or Upper New Red Sandstone of Europe, although some of the lower beds in the series may represent the underlying Permian, or the beds which, in Europe, immediately overlie the Coal-Measures, and thus form the uppermost division of the Palæozoic system, as the Trias constitutes the base of the Mesozoic.

The rocks of the Karoo system consist for the most part of more or less merely horizontal strata of sandstones and shales, ranging from 8,000 to 10,000 feet in thickness, and extensively traversed by outflows of igneous rocks. These intrusive sheets consist of the rock known as dolerite, and form flat table-lands rising above the general level of the Karoo, giving rise to the numerous "Tafelbergs" (table-mountains) to be met with in this part of South Africa.

It now remains to consider briefly the special features of the South African Karoo reptiles which render them of such remarkable interest and importance to the evolutionist. In this connection it has to be mentioned that there is a certain amount of difference of opinion in regard to the best collective name for these reptiles. In one of his earlier papers, Professor Owen proposed the name "Anomodontia" for the Dicynodonts and a certain British extinct reptile with which they have no real affinity. In a later work ("Palæontology") published in 1861 this name was, however, taken to include not only these Dicynodonts, but also the carnivorous types, although the definition was retained in the original sense as being applicable only to the Dicynodonts and associated forms.

According to modern views, these Anomodont reptiles represent a branch of reptilian stock (the Theromorpha), equal in value to a second branch (Ornithomorpha), which includes all other reptiles both living and extinct. This indicates succinctly the real importance of the Anomodonts, which seem to have been derived from the earlier Permian salamander-like creatures known as Labyrinthodonts, and which have certainly given origin to mammals. On the other hand, the second reptilian branch, which gave origin to birds, seems to have sprung from an entirely different group of primeval salamanders—the Microsaurians. It should be added that it is to the egg-laying mammals of Australasia (Monotremata), as represented by the duckbill or platypus, and the echidna or spiny anteater, that the Anomodont reptiles present the closest resemblance. These egg-laying mammals are, however, evidently specialised and aberrant forms, and it is, consequently, to their extinct and more generalised ancestors (which we may never discover) that we must look as constituting the direct links between reptiles and mammals. Still, as it is, the connection between the two groups is so close that some of the Anomodonts have actually been described as mammals.

To render the resemblances existing between Anomodonts and the Monotreme mammals apparent to the general reader, without the aid of illustrative diagrams, is, of course, a difficult matter. It may be mentioned, however, that the transition between the complex lower jaw of an ordinary reptile, articulated to the skull by means of a quadrate-bone, and the simple jaw of a mammal, which has no such intermediate connection, is exhibited by the Anomodonts; which also show how the tripartite knob, or condyle, forming the articulation of the skull with the vertebral column, passes into the paired knobs, or condyles, of the mammal. The bones of the pelvis and shoulder-girdle (shoulder-blade, coracoid, etc.), are, again, essentially similar in Anomodonts and Monotremes, and quite different from those of other reptiles; and a similar resemblance is noticeable in the form and perforations of the humerus or arm-bone, and in regard to the structure of the wrist and ankle joints. In a word, the difficulty is, not to discover resemblances, but to point out differences between the Anomodonts and the Monotremes, although the more typical representatives of the latter are undoubtedly reptiles in the strictest sense of that term.

Anomodonts are divisible into the following distinct groups. First, the Dicynodonts, in which the males (Dicynodon) are typically provided with a single pair of tusks in the upper jaw, while the females (Udenodon) were toothless; other forms having, however, crushing teeth on the palate; secondly, the Carnivorous, or Theriodont, type, like *Galesaurus*, in which the whole skull and dentition is marvellously mammal-like; thirdly, the Cotylosauria, in which the hinder part of the skull was partly roofed over; and, fourthly, the Pariasauria, in which the whole skull was roofed and its bones sculptured, so that the resemblance to a labyrinthodont salamander becomes exceedingly close. Some of these creatures, notably Pariasaurus, certain species of Dicynodon, and a few Theriodonts, were of enormous bodily size—as large as crocodiles.

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The Zambezi and its Sights.

No longer can it be said that the Victoria Falls are inaccessible, for now luxurious corridor trains are running made up of sleeping, dining and buffet cars, fitted up with library, writing room, bath rooms, observation platforms, and other accessories, performing the journey from Cape Town in three-and-a-half days, or from Beira in two-and-a-half days.

At a point some two miles before the end of the journey is reached, a fine view is obtained of the broad level valley of the Zambezi river, with the deep and precipitous Grand Cañon, zig-zagging like the path of a lightning flash for over forty miles through the hard basalt; while beyond is seen a glimpse of the calm broad river gliding peacefully towards the great chasm, whose presence, though hidden by the dark green foliage of the adjacent Rain forest, is clearly marked by a wall of whirling spray.

Long before reaching the falls columns of spray can be seen rising like clouds far into the air, and when, at intermediate stations, the train comes to a standstill the ear receives a dull distant roar of sound.

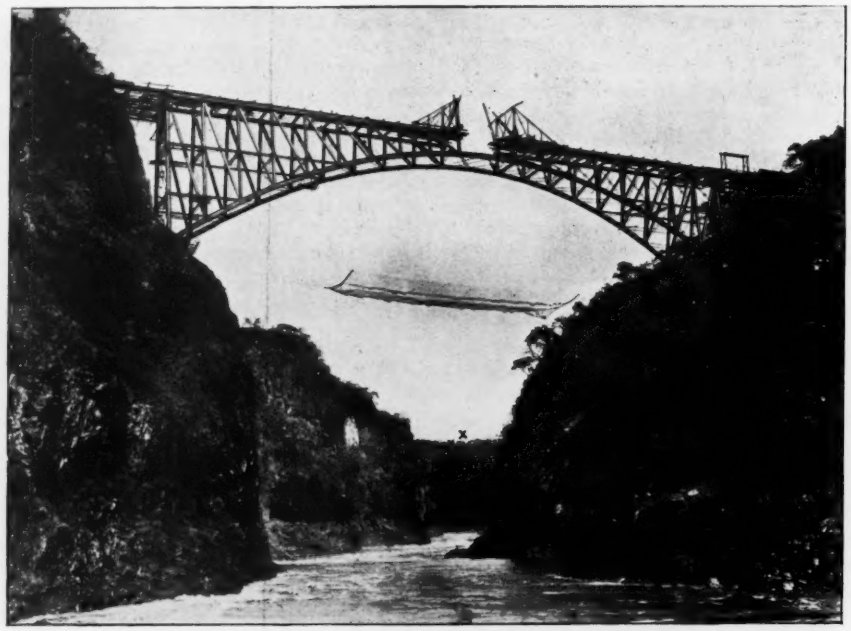
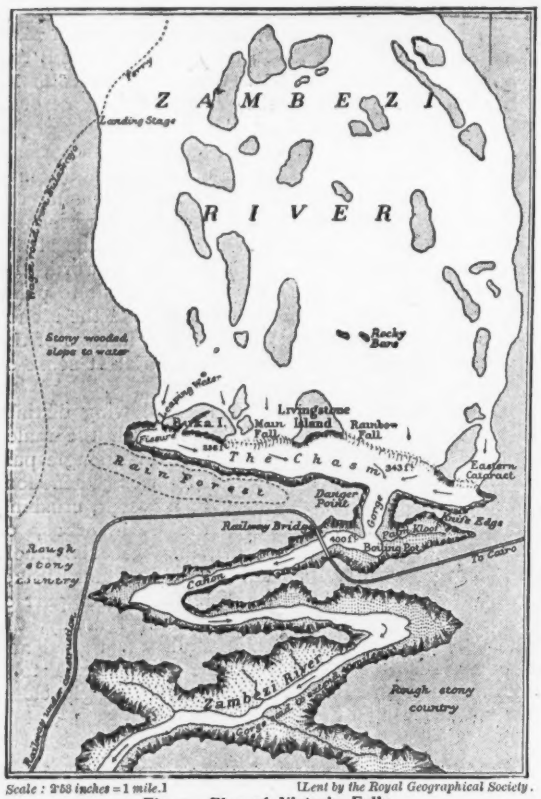


Fig. 2.—The Zambezi Railway Bridge across the Grand Cañon. The Roof of the hotel at which the Members of the Association will stay is just visible under the cross.



Scale: 2·55 inches = 1 mile. [Lent by the Royal Geographical Society.

Fig. 1.—Plan of Victoria Falls.

A glance at the accompanying plan (Fig. 1) is necessary to enable the geography of the river to be clearly understood. The mile-wide expanse of calm water, broken by numerous islands, is terminated suddenly by a long, narrow chasm stretching at right angles across the river; in wild, tumultuous foam of dazzling whiteness, this mass of water is hurled down some 260 to 380 feet with the roar of thunder into the dark depths, the very earth trembling from the incessant blows. The air drawn down by this irresistible volume of falling water, catches up the broken spray and whirls it in drenching gusts far above to form the cloud-like columns, which have been computed (by theodolite) during the rainy season as rising to a height of three thousand feet. From out the chasm there is no exit, except at a point about two-thirds of the distance across the river, where the opposite wall of basalt has been broken through in a narrow gorge. Gathered at this spot and contracted to less than 100 feet in width, the river here enters the Boiling Pot, so called, not because of its turbulence, but, on the contrary, from its placid swirling surface, that is broken only by countless air bubbles which rise from the depths of the main current. At the lower end or lip of the Boiling Pot the waters emerge in the form of a huge mill-race, which dashes itself against the precipitous wall of the cañon, half going to form the whirlpool at the foot of Palm Kloof, while the remainder, flowing at right angles to its former direction, rages between these stupendous cliffs for over forty miles.

When the river is low, small craft, if carefully handled, can approach to within a hundred yards of the lip of the falls at poins where the current is not swift.

It was in this way that Livingstone, who first visited the scene, came down stream in a "dug-out," landing on the island, which bears his name (see Fig. 1), and which is perched on the very brink of the chasm and almost in the middle of the falls. The views obtained from this point are by far the finest and most impressive, and for this reason it is well worth the while of visitors to refrain for the first day from stopping at the well-placed hotel on he south bank of the river, and to continue the journey until the new township of Livingstone on the north bank is reached; by doing this a glimpse only is caught of the cañon and falls while crossing the bridge, but it is a foretaste of what is to come. Then, chartering a boat on arrival, the quiet beauties of the upper river may be enjoyed while gliding down stream until Livingstone Island is reached. The remembrance of the first view from this vantage point will ever remain in the mind's eye.

Visitors are accustomed to stop on the south bank, where a comfortable and well-managed hotel has been erected by the Rhodesia Railways. From here it is but half a mile to the west end of the chasm, and all the wonders of this masterpiece of nature can be readily approached.

The Zambezi above the falls, save for a few rocky bars causing small rapids, is a beautiful wide river, flowing for many miles and dotted with numerous islands, which are thickly covered with tropical vegetation, forming a habitation not only for an infinite variety of waterfowl, but also for the treacherous crocodile and the bellowing hippopotamus. Game, too, is plentiful along its banks, and the tiger fish affords as good sport as the salmon. A particularly fine open reach about a mile above the falls has lately been the scene of a first regatta.

The bridge (Fig. 2) now completed, carrying the projected Cape to Cairo Railway, spans the Grand Cañon at a point just below the whirlpool, and is placed so as not to interfere with views of the falls. Far from being an eye-sore, the structure is of light and graceful design, eminently fitted for its purpose and to the locality; moreover, it seems to enable one to realise all the better the great depth of the gorge and the enormous scale on which Nature has wrought her work.

It consists of one main parabolic arch of 500 feet span, resting on blocks of concrete set in the sheer cliff, and, with two subsidiary end spans, the total length is brought up to 650 feet. The whole is supported on four steel bearing pins six feet long and 12 inches in diameter, and each pin takes a load of 1,640 tons.

Scaffolding being, of course, impossible, the bridge was made to support itself, as the two halves were built outwards. This was effected by attaching cables

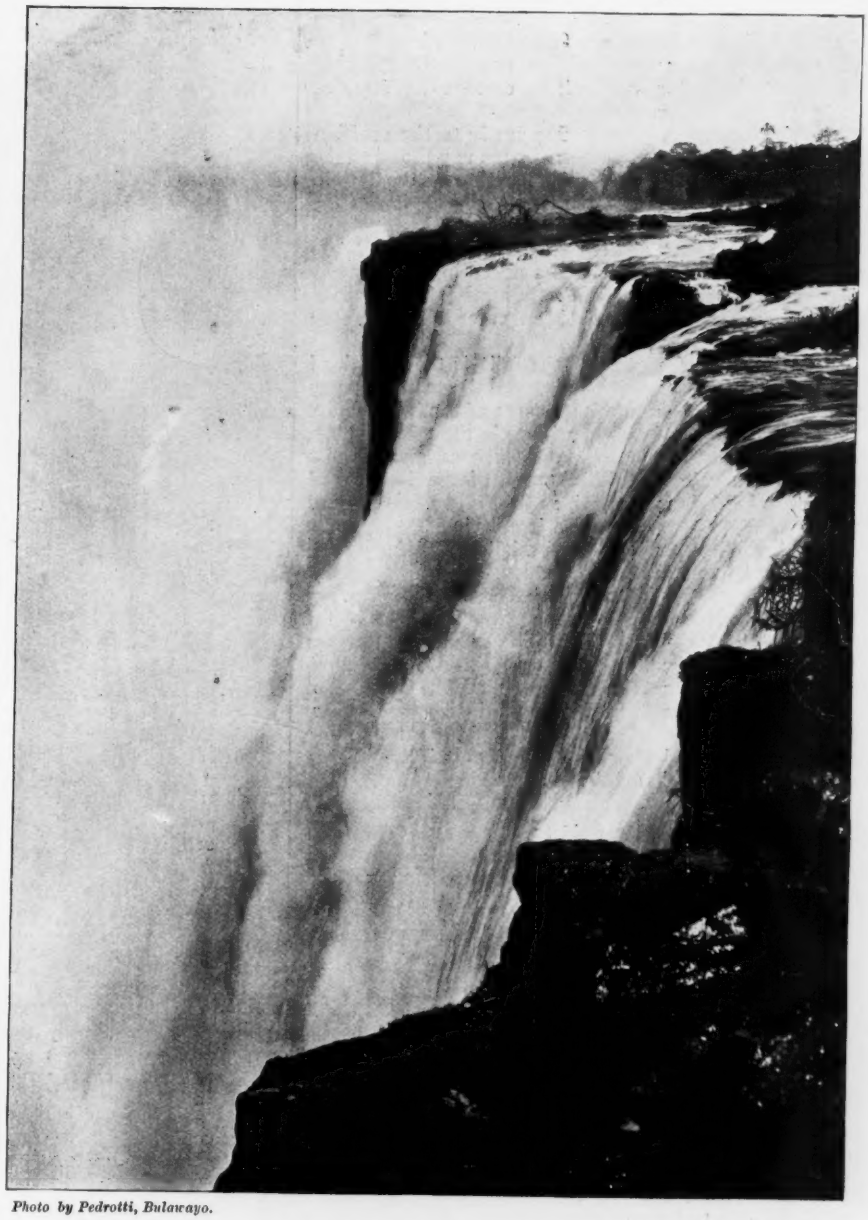


Photo by Pedrotti, Bulawayo.

Fig. 3.—The Victoria Falls. The Main Fall at low water, as seen from Livingstone Island.

to the steel work and anchoring them back in the solid rock behind, and as the electric cranes standing on the completed portion built the bridge forwards, extra cables were affixed until, on April 1st last, the two halves met.

The process by which the Zambezi has cut its erratic course has been traced by Mr. A. J. C. Molyneux in the *Geographical Journal*.* The basalt rock, when cooling, developed cracks and fissures, due to contraction, and assumed the columnar form. The cutting back of the falls is concluded to be due to the water falling down upon and into these cracks; with the constant vibration the columns are rent asunder and fall in huge flakes into the chasm. Little evidence is seen of the rock being worn away by attrition, the blocks newly fallen into the chasm still retaining their sharp angles. These blocks gradually disappear into the Grand Cañon impelled by the rush of the current, and are constantly grinding down and deepening the bed, to emerge as rounded pebbles at the eastern end.

The zigzags are held to be due partly to the position of the islands that studded the river (as now), and to the existence of master joints and fissures in the basalt. Where an island occurs there the erosive action of the water has no effect, hence the extraordinary isolated bluffs and knife edges of rock connecting them. There are no signs that the earth was cracked in this form by some seismic convulsion, or that a material softer than the surrounding basalt has been eaten away by the action of the water.

One of the chief glories of the falls is the wealth of colour, not only in the rich foliage of the tropical vegetation, or the dazzling white masses of tumbling foam, but in the prismatic bows sparkling in the mist. When walking between the forest and the chasm, a small bow may be seen almost within touch of the hand, and faithfully following; then there is the more ordinary type spanning the gorge or irradiating the gloomy depths below, and rendered especially beautiful by the soft rays of the moon.

Many members of the British Association who are visiting South Africa intend to travel as far north as the Zambezi. The climate at that season of the year will be found dry and warm, while mosquitoes and fever are happily absent. The volume of water, too, has been diminishing since May, consequently the curtain of spray will be in great measure drawn aside, disclosing the beauties of the falling water and the depths of the chasm.

* Vol. xxv., No. 1, 1905.

South African Association for the Advancement of Science.

From a suggestion to arrange for an Annual Congress of Engineers in South Africa arose the larger idea of a federated body in science on the model of the home British Association. The first practical step was taken in March, 1901, at a meeting held in Cape Town, Sir Charles Metcalfe presiding. The main impetus to the movement for such an organisation was given by Mr. T. Reunert, M.Inst.C.E., a resident of Johannesburg, and he, indeed, may be regarded as the father and founder of the South African Association. The first meeting was held at Cape Town in 1903, under the Presidency of Sir David Gill, with a membership of 700, since increased to over 2000; the second at Johannesburg, Sir C. Metcalfe, presiding. No meeting is to be held in the present year.

The Royal Observatory at the Cape.

THE first official document relating to the Royal Observatory at the Cape of Good Hope is a minute of proceedings of a meeting of "Commissioners appointed by Act of Parliament for more effectually discovering the longitude at sea," it is dated February 3, 1820. The establishment of an observatory was proposed at this meeting by Mr. Davies Gilbert, M.P., and seconded by Sir Joseph Banks, P.R.S. By an Order in Council authority was given on October 20, 1820, for the establishment of a staff, consisting of an astronomer and

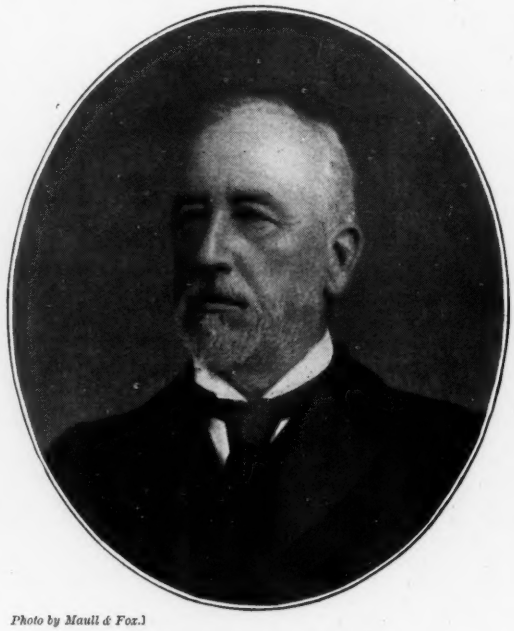


Photo by Maull & Fox.

SIR DAVID GILL, K.C.B., F.R.S.,
H.M. Astronomer at the Cape of Good Hope.

assistant astronomer. The equipment was a 25-feet zenith micrometer by Troughton, a transit by Dollond, a 6-foot mural circle by Jones, and an equatorial sector and a 6-feet Newtonian reflector were provided from Greenwich. Although the primary object in founding the observatory was to provide ships sailing to India and the East with accurate time, it was recognised that a suitable opportunity had presented itself for founding a great national observatory in the Southern Hemisphere. The first astronomer was the Rev. Fearon Fallows, F.R.S., who arrived at the Cape in 1821, bringing with him some portable instruments. His first instructions were to find a suitable site. The present one, it should be said, was chosen after trying several others, which had to be abandoned on account of drifting sand or of cloud, and many were the annoyances and discomforts encountered during these preliminary efforts. For over three years Fallows lived in a hut superintending the building of the observatory. At last, in 1829, he found it possible to begin regular astronomical work, but he could not accomplish much

through want of proper assistance. Before his death, in 1831, he had observed over 3,000 transits, and had made several hundred circle observations, which were subsequently reduced by Airy. Thomas Henderson, who succeeded Fallows, remained at the Cape for 14 months, but in that short time he had made a large number of first-rate observations, the most important being meridian places of α Centauri, from which he found a parallax of about $1''$.

Highly valuable observations were made by the next astronomer, Sir Thomas Maclear (1834 to 1870), but owing to inadequate assistance the reduction of a large part of them had to be left to his successors. Mr. E. J. Stone, F.R.S., who succeeded him, received, however, instructions to reduce them as quickly as possible, and from these observations three star catalogues have been formed.

In 1879, when Mr. (now Sir) David Gill took up his duties, there were only three assistants on the staff and three or four computers, the latter on the same footing as at Greenwich; now the scientific staff numbers 12, with 10 to 15 male and female computers. The instrumental equipment, too, has been greatly increased. In 1880 it consisted chiefly of the transit circle and a 7-inch equatorial, but the additions since that date include the Victoria telescope, the gift of the late Mr. F. McClean, F.R.S., a new and specially designed transit circle, an elaborate astronomical clock recently installed, an astrographic telescope, employed chiefly on the international "Carte du Ciel," a 7-inch heliometer, and numerous smaller instruments.

Of the work already completed by Sir David Gill, perhaps the most important is the determination of the solar parallax from observations of the minor planets Victoria, Sappho, and Iris. Over 20 observatories contributed towards this work, and at the Cape, where nearly all the reductions were made, more than 16,000 observations were made with the heliometer. The result is a solar parallax of nearly $8''{\cdot}80$, corresponding to a distance of the earth from the sun of 92,874,000 miles, a value generally adopted in national Ephemerides. We may refer also to the compilation of three large star catalogues, the reduction of Maclear's observations, the determination of stellar parallax with the heliometer, the work done with the astrographic equatorial for the "Carte du Ciel" and for the "Cape Photographic Durchmusterung." The latter is a catalogue containing the places, reliable to $1''$, and magnitudes of 454,875 stars from declination -19° to the south pole. Some 2,500 plates were taken for this, and the arduous work of measuring them and making the catalogue was undertaken by Prof. Kapteyn. During the course of measurement a great number of interesting variable stars were detected, also a star with the greatest known proper motion. The measurement of the plates, which is still going on, is entrusted to ladies. So far about 800 plates have been measured, containing nearly half a million stars.

Another piece of work under Sir David Gill's supervision is the partly-completed geodetic survey of South Africa.

The Victoria telescope and accessories, with the dome and attached laboratories, was the gift of Mr. McClean, and is devoted to the study of astrophysics. The dome is provided with a rising floor which is worked by hydraulic machinery. The telescope itself consists essentially of two parallel tubes tied together, one for a 24-inch photographic lens, the other for an 18-inch visual; and there can be attached to it two large objective prisms or a large slit spectroscope for determinations of velocity in the line of sight. Many interesting spectra have already been photographed and measured.

The new transit circle has been specially designed to be free from the effects of temperature change, and is being used to make the most refined fundamental observations. It can be readily reversed in its trunnions, can have the object-glass end and the eye end interchanged, and is fitted with Repsold's micrometer with moving wire for observing transits. To bring this installation into proper working order and to determine all such instrumental constants as division errors of the circles, periodic errors of screws, and other details, necessarily consumes time and demands much patience, but in his last report, His Majesty's astronomer stated that "the new transit circle will be brought into regular catalogue observing work from the beginning of 1905." The old transit circle is still in use for the time service, an important part of the observatory's work. The instant of Greenwich noon is signalled every day to Simon's Town, Cape Town, Port Elizabeth, and East London, and all the railway clocks on the Wynberg line are automatically set every hour, a system which is being extended to other portions of the Government railways.

To provide fixed meridian marks for azimuth reference, deep pits have been sunk, and on the bed rock at the bottom of them the marks rest. A clock for use in connection with the new transit circle has also been installed, the pendulum of which swings in an air-tight case, in which the air is automatically kept at a uniform pressure and temperature.

The South African Museum, Cape Town.

THE only institution connected with zoology in South Africa which is provided with a scientific staff and is doing original work, apart from the mere acquisition and arrangement of specimens, is the South African Museum at Cape Town. This museum was founded by the late Sir George Grey when Governor of the Colony in 1855, and its first Curator was Edgar Leopold Layard (a brother of Layard of Nineveh fame), who was well-known as an enthusiastic naturalist. Layard was the author of many books and papers on zoology, and likewise an excellent field-naturalist. His best known book is his "Birds of South Africa," of which the first edition was published in 1867. The second edition, in preparing which Layard was assisted by Dr. Bowdler Sharpe, was completed in 1884, and has until quite lately been the recognised book of reference on South African ornithology.

In 1872 Layard left the Cape to take up a consular appointment in New Caledonia, and was succeeded by Mr. Roland Trimen, F.R.S., distinguished as an entomologist, and especially for his knowledge of the Lepidoptera. Mr. Trimen held the appointment for 23 years. His excellent work on the butterflies of Cape Colony and surrounding districts

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("Rhopalocera Africæ Australis") will always render his name well known in the annals of African zoology.

In 1895 Mr. Trimen resigned his appointment for reasons of health, and in December of that year Mr. William Lutley Sclater, at that time a science master at Eton College, was selected by the trustees to succeed him, and was appointed Director of the Museum.

Mr. Sclater arrived at Cape Town in March, 1896, just in time to preside at the removal of the collections from the old quarters in which they had been previously kept, to the new and commodious building which had been completed in 1895, and which is situated in the public garden in the best part of Cape Town near the Cathedral and House of Parliament. The building is of two storeys, the ground floor being devoted to the geological and mineralogical collections and the invertebrata, and the upper floor to the exhibition of the mammals, birds, reptiles, and fishes of South Africa, of which there is a very good illustrative series, though many *lacunæ* remain to be filled up. Mr. Sclater, besides his general duties as Director, has charge of the collection of vertebrates. As regards the invertebrates, he is ably assisted by Mr. L. A. Péringuey, the Assistant Director, who is a well-known authority on Coleoptera and other insects. The first assistant, Dr. W. F. Purcell, who is also well known for his original researches on the scorpions and spiders of South Africa, has charge of a portion of the invertebrata. A fourth member of the zoological staff is Dr. J. D. F. Gilchrist, who is honorary keeper of the marine invertebrates, but whose main duties are to develop the fisheries of the Cape seas, which are under the charge of the Agricultural Department of the Colonial Government.

The keeper of the important department of geology and mineralogy at the South African Museum is Dr. G. S. Corstorphine, who is associated with Mr. E. H. L. Schwarz, of the Geological Survey of the Colony, and they have the care of the fossils and other specimens collected by the Survey.

Two good pieces of work have been started by the present Director since his appointment. These are a series of manuals on the fauna of Africa south of the Zambezi, and a periodical called "Annals of the South African Museum." Of the first of these the two volumes on the mammals were prepared by Mr. Sclater in 1900 and 1901.

The "Birds of South Africa" was entrusted to the late Dr. Stark, a well-known authority on the subject, and the first volume was published in 1900. But Stark, who volunteered for the medical service of the English Army, unfortunately lost his life in the siege of Ladysmith, and the second and third volumes on the birds have been written by Mr. Sclater, with some assistance from Stark's field notes. The fourth volume concluding this work is now in the press.

The "Annals of the South African Museum" contain scientific memoirs, prepared mostly by the members of the official staff of the Museum or other naturalists working with them. Two volumes and twelve parts have already been issued.

Naturalists will see, therefore, that much good work has been done in the South African Museum, and that more is likely to come from it. We should also be grateful to the three Trustees of the Museum, Mr. Merriman, Sir David Gill, and Dr. T. Muir, Superintendent-General of Education, three well-known personages in Cape Town, who have assisted in every way the efforts to increase the usefulness of the institution.

Star Map—No. 12.

The South Polar Region.

THIS map, though not issued in its proper order of sequence (Nos. 1, 2, and 3 having appeared in the last three issues of "KNOWLEDGE"), may be useful to those visiting the Southern hemisphere.

The Southern Cross (Crux) is always considered as the ruling constellation of austral skies. It is situated in the Milky Way, just to one side of the "Coal Sack," a space quite devoid of stars. Another group of stars of very similar arrangement (ϵ and ι Carinæ, with δ and κ Valæ) are often mistaken for it, and is consequently known as "The False Cross."

Two peculiar objects are the Great and Little Magellanic Clouds, looking like detached portions of the Milky Way. Examined with a powerful telescope, these are found to consist of masses of star clusters and detached nebulæ, and would seem likely to be altogether separate "universes" at a vast distance off.

Around the actual South Pole is a noticeable absence of conspicuous stars, and though this feature alone enables one to judge of the general position, it is more difficult to recognise the true South from the stars than it is to find true North when Polaris is visible. Yet beyond 20 to 30 degrees from the Pole occurs a number of bright and easily recognised stars. The upright shaft of the Southern Cross points nearly North and South, and the line being continued through the South Pole, runs into the Little Magellanic Cloud. To be more exact, however, one should continue this line further, and thus find Achernar (α Eridani). A line joining this with β Centauri (the nearer of the so-called "pointers" to the Southern Cross) runs directly through the South Pole, which is just about midway between the two. Among the more specially interesting objects in this region are:—

Cluster 47 Toucani (0h. 20m. — 72° 39′). A fine star cluster visible to the naked eye as a hazy star. Over 2000 stars, including 6 variables, are included in it.

α *Crucis* (*Acrux*) XII.h. 21m. — 62° 33′) is a triple star. Magnitudes, 1·5, 1·8, and 6.

κ *Crucis* (XII. h. 43m. — 59° 30′) is a cluster of over 100 stars. They are of many different colours, and present a beautiful sight in a good telescope.

α *Centauri* (*Rigil al Kentaurus*) (XIV.h. 23m. — 60° 26′) is well known as being the nearest star. Yet its distance is not easy to realise. It is computed to be about two hundred thousand times the mean distance of the Sun from the earth. The light takes over 3½ years to come to us. This star has a parallax of 0″·75. It is a binary, the two stars being at a distance of 21″·6, and of nearly equal size.

α *Argus*(*Canopus*) (VI.h. 21m — 52° 38′) is the second brightest star in the heavens, being classified at — 1·0 magnitude.

η *Carinæ or Argus* (X.h. 41m. — 59° 10′) is a most peculiar variable. Two hundred years ago it was of the 4th magnitude. In 1837 it increased in brightness till it became a 1st magnitude. It then diminished a little, but six years later had a brilliancy comparable to that of Sirius, after which it gradually dwindled away to the 7th magnitude. It is surrounded by a remarkable nebula, known as the "Keyhole" on account of the well-defined dark opening in its centre.

Quite recently careful photographic surveys have been made of the Small Magellanic Cloud at the Arequipa Observatory. These prove the existence of a very large number of variable stars, there being within this region a proportion of one variable to every 308 stars, which is nearly ten times the ordinary proportion. One star of the 13th magnitude was found to have a proper motion amounting to + 0·13 s. in R.A., and + 0″·42 in Dec.

Supplement to "Knowledge & Scientific News,"
SPECIAL NUMBER, *July* 15th, 1905.
(British Association Meeting.)

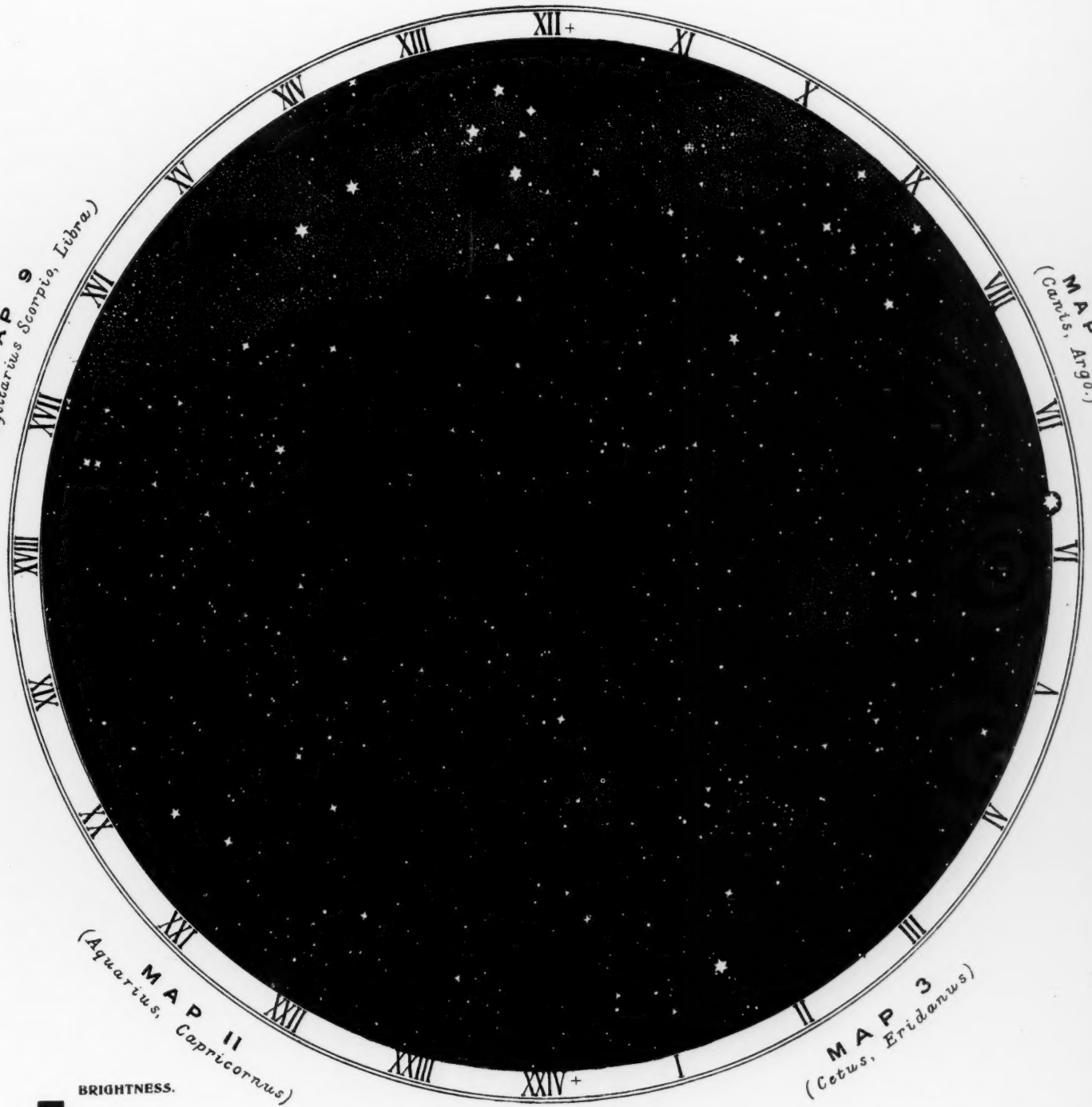
MAP 7
(*Virgo, Hydra, Centaurus*)

MAP 9
(*Sagittarius Scorpio, Libra*)

MAP 5
(*Canis, Argo.*)

MAP 11
(*Aquarius, Capricornus*)

MAP 3
(*Cetus, Eridanus*)



BRIGHTNESS.

- 1st Mag.
- 2nd ,,
- 3rd ,,
- 4th ,,
- 5th ,,
- 6th ,,
- Variable.
- Nebula.

MAP No. 12.

The South Polar Region.

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Photography Abroad.

Camera Work for Travellers.

DOUBTLESS a large number of the members of the British Association who will go to South Africa, purpose taking cameras with them in order to bring home records of their visit. Many of them will be experienced photographers who know exactly what they want and how to get it, but there will certainly be others who have done little if any work of this kind before, and some may hesitate as to whether it is worth while to run the risk of failure, seeing the expense and trouble that would be incurred. Accordingly it is to the inexperienced that these notes are addressed.

The uncertainty and difficulty that used to beset photography abroad have almost disappeared. The experience by which we are now able to profit, and the efforts of manufacturers to make everything easy, have reduced the practice of photography, such as is here referred to, to the simplest of operations wherever it may be carried on. No one, therefore, need hesitate to take a camera for fear their trouble will be wasted.

But it is necessary to note that apparatus and methods that would well serve, and, indeed, best serve, if photography were the primary object of the visit, would not only be out of place and a constant source of annoyance, but quite impracticable under the existing circumstances.

Apparatus, its Weight and Bulk.—We have often been told by persons about to travel, that weight is scarcely worth consideration, and that bulk, too, is a minor matter, because the luggage is carried by servants; but that rough usage must be guarded against, for packages are sure to be knocked about. In the present case, however, these circumstances will be reversed. Each will carry his own camera and be able to take reasonable care of it; therefore, weight and bulk become very important items. This at once excludes all box cameras and non-folding apparatus; except, indeed, for the enthusiast regardless whether his photography prove a burden to himself, and perhaps also a nuisance to other people. There are many very small cameras that may be exceptions to this generalisation, but we have in view the production of photographs not smaller than about quarter-plate size, $4\frac{1}{4}$ x $3\frac{1}{4}$ inches.

In judging of weight and bulk, it is important to consider two distinct things, namely, the apparatus that has to be carried about when in use, and also the apparatus and material that will be left at the hotel, such as the stock of sensitive material, developers, and so on. Concerning the latter, little need be said, but purchasers are often deceived as to the portability of the camera and what must be taken with it whenever it is to be used. There is no gain in having a compact and light camera if it has to be carried in a large and heavy case. The apparatus must be judged of when in exactly the condition in which it will come into play, with everything ready for making a series of exposures. If any part is loose, such as a changing box, backs, or other contrivances for carrying the plates of films, this part must be included. If glass plates are to be used, a full stock, six, or a dozen, of these should be added, for their weight is far from negligible.

The Camera.—Having regard to the circumstances enumerated, the apparatus that may be considered the most suitable is an entirely self-contained camera of the folding kind, arranged to take spools of rolled films. A folding pocket Kodak for quarter-plate pictures that we ourselves use is but little over an inch and a half in thickness, and a very substantial leather case provided for it is under two inches in thickness. Such a package is no burden, and is absolutely self-contained. There are other similar cameras to be obtained, and if the thickness may be increased a little, folding cameras of greater scope and of more general applicability, though probably not more useful on such a visit as this, are available.

The Lens.—By paying three or four pounds more, a first-class lens may be substituted for the ordinary one. This, of course, would be an advantage, but in the present instance so small a one that we do not recommend it, except for those who know that the work they mean to do will be benefited by it. The gain in using a costly lens is a better definition at the margins of the picture, with the possibility, therefore, of using a larger diaphragm and consequently giving a shorter exposure. But under the ordinary conditions that may be expected, the diaphragm of the cheaper lens may be small enough to secure good definition at the same time that the exposure is as short as is likely to be desirable.

Other Apparatus.—As to a tripod, if one be taken it should be a light one. Some metal stands are perfect in every way, compact and light, but the sliding parts of the legs if bruised are likely to become fixed or irreparably damaged, therefore a wooden one is preferable. But if a tripod is taken it will probably not be used, for experience shows that on such occasions a stand is so seldom wanted that it is not habitually carried with the camera, and that when the need for it does arise, it is not at hand. It may also be noted that it takes much longer to mount a camera on a tripod than to use it in the hand, and that when accompanying a party there is often no opportunity to take things leisurely.

It is a distinct advantage to have an "everset" shutter, because the "setting" of the shutter that is otherwise necessary is the one operation most likely to be forgotten. The only apparatus that it is desirable to carry besides what the word "camera" in its inclusive sense signifies, is an exposure meter or actinometer for use as described below. There are several kinds of these, some as small as a locket, the essential feature being that they contain sensitive paper that darkens on exposure, and gives an indication of the intensity of the light by noticing the time necessary to expose it for the production of a colour equal in depth to a standard tint.

Development.—In hot countries and trying climates it is not safe to keep exposed films long between exposure and development. It is possible to send them or bring them home for treatment at leisure, but it must be remembered that sensitive material is much more liable to injury from adverse climatic influences after than before exposure, and that any delay incurs risk and is practically certain to cause deterioration. The best method is to develop as soon after exposure as possible, that is, within a day or two, and here it is that the

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use of rollable films presents an advantage that can scarcely be overrated. By means of a "developing machine" a whole roll of a dozen exposures can be developed at once, without any need for a dark room or its equivalent, and with a very much greater certainty of a good proportion of successful negatives than can be claimed for any other method. As a recent experience of what may be expected from such a manner of work, it may be mentioned that a friend of the writer, who does not claim to be even an amateur photographer, made a few months ago about three hundred and fifty exposures in and near the Soudan, and of these he has lost only ten or a dozen, which were spoilt by faults in using the camera, such as forgetting to wind up a new film after exposure. All the rest are useful, and a very large proportion technically perfect, without stains or faults. In using the machine—which is only a tank to hold the developer, and an arrangement for winding the length of film into a convenient roll for treatment—the best way is to take the developing powders that the makers provide in suitable small packets, and to follow the instructions as to time, &c., that are given with the apparatus.

Packing, &c.—The packing of the stock of sensitive films may well be left to the makers, for their considerable experience in sending such material abroad may be relied on; but it should be seen that they clearly understand where the material is to be taken to. It is usual to put each spool of film into a tin box, and if the lid is made secure by means of adhesive plaster instead of being soldered down, the tins can be used more than once—or for re-packing.

Rehearsal and General Procedure.—Before starting, a few exposures should be made and developed by way of rehearsal. A spool of six films, and, if necessary, a second similar one, will serve well for this purpose. With the shutter set at the twenty-fifth of a second, and the lens diaphragm at f/11, f/16, and f/22 respectively for each of three exposures on a suitable subject in good light, a sufficient idea will be obtained as to the conditions necessary. The exposure meter should be used at the same time, noting the number of seconds required to produce the standard tint. To adjust a subsequent exposure to an alteration in the value of the light, as shown by the different time necessary to produce the standard tint in the exposure meter, it is better to vary the lens aperture, for this change can be relied on, each aperture giving double the exposure of the next smaller. The shutter speeds are generally not exactly as marked, and it is possible that by pushing the pointer to the figure that indicates half the exposure just given, there may be no alteration in the duration of the exposure. With constant fine weather, it may not be necessary to test the light perhaps for days together, but if the weather changes, or the subject is unduly shaded, as it may be in towns or under trees, then the exposure meter should be used. If a longer exposure becomes necessary than the one suggested, the camera should be supported on or against some steady object, such as a wall, a gate, or a tree. Then, unless the times of the other settings of the shutter have been experimentally determined, it will be best to set the shutter index to "B" or "bulb," when the shutter will remain open as long as the bulb is pressed, and will shut as soon as it is released. Exposures of a quarter of a second and upward can be easily given in this way after a little practice.

The Great Zimbabwe, Rhodesia.

AMONG the scientific matters which will be considered by the British Association in the course of its visit to South Africa is the question of the origin of the ancient ruins which are scattered so profusely over the whole of Southern Rhodesia—an area extending some six hundred miles from east to west, and five hundred miles from north to south.

This territory, situated far inland from the shores of the Indian Ocean, appears to have some connection with the ancient history of the Near East, a conclusion resulting from explorations among these ruins which have been carried on during recent years. It is a conclusion which is intensely fascinating, not only to the archæologist and antiquarian, but to the Biblical student, for here are to be found the remains of an enormous gold-mining industry and the traces of an ancient civilisation, for which Semitic people, most probably from Southern Arabia, are responsible.

The age of the oldest type of ruined buildings is now believed to date back contemporaneously with, if not earlier than, the Solomonic gold period of Holy Writ, though much later waves of Semitic colonists have undoubtedly carried on in this territory the enterprise of their ancestors. It also appears that the most ancient type of buildings in Rhodesia yields evidence of Phallic religion, and of the worship of Baal and Ashtaroth as described in the Old Testament.

The main objective of these successions of colonists was that of gold-winning, for the remains of thousands of gold workings occupy the area in which the ruins are found. So extensive are these gold mines that experts believe that gold to the modern value of at least seventy-five million pounds sterling has been extracted in ancient times from the reefs of this country.

From the recently-published work* written by Mr. R. N. Hall, F.R.G.S., who spent over two years in exploring the central group of ruins, we gather that the structures are of various ages covering periods extending from the most remote antiquity down to mediæval times.

These buildings, which are admitted to be the greatest archæological wonder of the Southern Hemisphere, are in groups, but the groups are connected with each other, and also with the coast at the ancient port of Sofala, by chains of massive forts at a distance of a few miles from each other, and these forts occupy strategic points protecting well-defined routes of the ancients throughout the country. Messrs. Hall and Neal state† that there are at least some three or four hundred ruins or sets of ruins throughout the region of Southern Zambesia, and descriptions of many of these buildings and of the associated gold workings, together with information as to the ancient architecture, are set forth in detail.

The most important group of buildings is that of the Great Zimbabwe, *i.e.*, "the great buildings of stones." This is situated some two hundred miles inland west of the shore of the Indian Ocean at Sofala. Zimbabwe, both by the size of its buildings, the area covered (one and a half miles by one and a quarter miles), by its position, appears to have been the chief metropolitan centre of the ancient gold miners, and is undoubtedly

* "*Great Zimbabwe*" (Methuen)
† "*The Ancient Ruins of Rhodesia*" (Methuen).

among the oldest type of building to be found in the country. This group was re-discovered in 1868 by Adam Renders, an elephant hunter. In 1891 Mr. Theodore Bent visited the place and described it in his "Ruined Cities of Mashonaland." But in the days when Mr. Bent visited Zimbabwe, the whole of the ruins were in a buried condition, yet so far as he was able to describe these structures his account is perfectly reliable and of permanent value for the antiquarian.

During 1902-4 the Government of Rhodesia engaged Mr. Hall to explore this group of ruins and to take measures to secure their preservation. The interiors had, in the course of long centuries, become filled in with silted soil, the *débris* of later occupiers, and fallen walls, as well as rank sub-tropical vegetation. This gradual filling-up process had led to the burial of the ancient floors to a depth varying from six to twelve feet. With the aid of a gang of native labourers the work of clearing the interiors of some of the important portions of the buildings was taken in hand, but the operations, though carried on for over two years, revealed only a portion of the ruined structures comprised within the limits of the "Dead City."

Enough, however, was disclosed to prove beyond question the past existence of Phallic litholations, and solar worship of a very old cult practised by the original occupiers. Not only were entirely fresh features of ancient architecture discovered, but such of the original floors as were uncovered yielded priceless relics of prehistoric times, including gold ornaments and religious emblems in rich profusion. When it is stated that thousands of feet in length of narrow and labyrinthine passages which had become lost to sight were discovered and cleared of *débris*, one can understand to what extent the ruins had in the course of ages been covered over. But the area occupied by this group is so extensive, and the distinct ruins are so numerous, that these operations, carried on under great difficulty and necessitating the constant exercise of care and patience during the exploration, still leave the great bulk of the Zimbabwe ruins buried and unexamined. It is quite possible that the buildings contain many more secrets of an important character to be unravelled by the archæologist.

The ruins of the Great Zimbabwe consist of three main sets of structures—(1), the Elliptical Temple with the conical tower; (2), the Acropolis or Hill Ruins of bewildering extent on Zimbabwe Hill; and (3), the Valley of Ruins, these latter being a conglomeration of smaller ruins of all ages occupying a large area in the Zimbabwe Valley.

Fig. 1.—Interior of Elliptical Temple, looking East, showing Conical Tower.—Great Zimbabwe.

The chief archæological interest, however, centres in the Elliptical Temple (Fig. 1), an object arousing wonder and even sheer amazement to all who visit these ruins. Its massive and stupendous walls, gracefully sweeping curves, and most excellent workmanship and decorative mural patterns, at once rivet the attention. The plan of the building is elliptical, while the ends of the walls, sides of entrances, and buttresses are all rounded. The angular form of building is absent. The walls are very substantially built of dressed granite blocks laid without mortar or cement, and have bases averaging from 7 ft. to 16 ft. in width, and are beautifully and skilfully constructed not only on their exterior faces, but in their internal portions. The walls average a height of from 24 ft. to 31 ft., the main east wall being 16 ft. wide at its base, but at a height of 30 ft. its summit is 8 ft. in width. The leanback or batter-back of the faces of the wall gives an

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Eastern appearance to the building, which is very striking. The summit of the main east wall was once decorated with tall granite monoliths, the bases of some twenty-six monoliths still remaining *in situ*. The outer face of the east wall bears a pattern of chevron in two rows worked in granite blocks (Fig. 2). This pattern is one of the earliest decorative designs known to research, and is the ancient emblem of Water and Fertility of the old Nature worshippers.

The Conical Tower, 32 ft. in height, is one of the principal architectural features of this building. Its lines are worked out with marvellous skill. It is perfectly solid, and with it is associated a high stone platform approached by steps. The tower is considered by

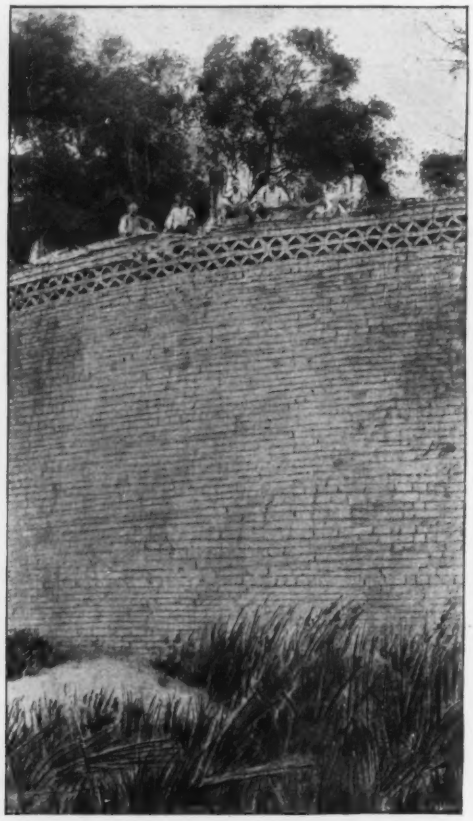

Fig. 2.—Chevron Pattern on Eastern Wall, Elliptical Temple, Great Zimbabwe.

many leading men of science to be identical in purpose, if not in general form, with the Baal towers of Arabia, Phœnicia, Canaan, and Babylon, referred to in Holy Writ.

The interior of this immense building is divided into some fifteen enclosures, and there is no less than 700 ft. length of passages within the walls, the most famous being the Parallel Passage, which leads directly from the north or main entrance into the Sacred Enclosure in which stands the Conical Tower. Many leading European experts place the age of the Temple at some period between 1600 and 1100 B.C.

There is great similarity between the architecture of Zimbabwe and that of several ancient temples in South Arabia. The Temple at Zimbabwe is admitted to be the finest example of an ancient Nature worshipping shrine known to the world. No inscriptions have been found at Zimbabwe, the earliest inscriptions found in any Phœnician Temple being not older than 700 B.C.

At Zimbabwe there are evidences of an ancient civilisation and arts whose only parallel in many respects, especially in their associations, is to be found in the ancient kingdoms of South Arabia. According to the Scriptures, and ancient Roman and Grecian historians, the Sabæans of South Arabia were the gold purveyors of the then known world. Rhodesia contains the most ancient and most extensive gold mines yet discovered.

The Gold Mines and Gold Production.

THE history of Africa as a gold producer dates back to very early times. It was not, however, till comparatively recently that South Africa, as now known, was found to be a gold-bearing country. In 1882 the De Kaap goldfields were started, while it was three years later before the famous Sheba mine was discovered and the town of Barberton founded. The existence of gold, however, had long been surmised, and was actually discovered in 1868, Carl Mauch referring to it as occurring near the Oliphants River. In 1870 it was found in the Murchison Range, and the next discovery was in the Lydenburg district, at Pilgrim's Rest. In 1884 Struben Brothers started a 5-stamp battery on the farm Weltevreden, in the western district of the Transvaal, for quartz mining, which is very dissimilar to "banket," as the huge conglomerate bed of the Witwatersrand basin has come to be known. The deposits consist of quartz pebbles held together by a siliceous cement containing iron pyrites. The gold exists in the finest particles, showing sharp crystalline structure on examination by the microscope, as against the rounded forms, through attrition, in alluvial deposits. Gold was first panned from the "banket" beds of the Witwatersrand (or white waters ridge) in 1885, and in 1886 Johannesburg, the "Golden City," sprang into existence, as if from the wand of a fairy. The goldfield is situated on a plain about 6,000 feet above the sea-level, across which the northern outcrop of the gold basin rises slightly, and roughly represents the watershed between the Atlantic and Indian Oceans. The formation has been traced practically continuously for about 60 miles along the strike of the Main Reef, from Randfontein in the west to Holfontein in the east. A length of about 12 miles of this, with the Langlaagte Block B on the west and Knights on the east, is described as the "Central Rand," the companies operating which are stated to be responsible for about three-fourths of the gold won down to the outbreak of war in 1899. But the conglomerate beds have been traced over far greater areas, outcrops and borings having revealed continuity for 164 miles, while nearly 150 miles are estimated to be concealed by recent measures and short interruptions by faults or dykes. Judging from the dip of the formation at the central northern outcrop of the basin, it was for some time supposed that the depth would become prohibitive for mining at a distance (say) of two miles. Enormous engineering feats will apparently not have to be undertaken, as exploration has shown

that the curve between the north and presumed south outcrops is not symmetrical. In fact, the bed of the area has a more or less level bottom, being a series of synclines and anticlines.

Gold mining is everywhere a highly speculative undertaking, but in the Transvaal great reliance can be placed upon the regularity of the ore deposits. This justifies very heavy preparatory outlays. It is, for instance, estimated that before an ordinary deep-level mine can reach the producing stage the expenditure on boring, sinking (say) two shafts, the erection of a mill of 400 to 600 stamp capacity, the connecting of the two shafts, and driving on the reefs to expose a sufficient quantity of ore to keep the mill in operation amounts to something like one million sterling. This, of course, refers to a proposition where the reef lies at a depth of about 3,000 feet, while the area of such a mine would be something like 1,000 claims. When the ore is "brought to grass," as it is termed, a series of scientific processes is brought into play in order to extract the precious metal. The most approved mechanical appliances and chemical methods are drawn upon, and the leaders of the industry are ever on the look-out for improvements, as the nearer perfection is attained—that is, 100 per cent. extraction—the more profitable is the result. The various processes are complicated and delicate in the extreme, and as each particle of gold is mixed with, perhaps, 60,000 particles of rubbish, as the Transvaal tonnage averaged in 1903, it can easily be conceived that the slightest miscarriage would be disastrous.

A great deal of attention has been given within the past 12 months to tube, or flint, mills. Such a mill at the Glen Deep consists of an iron cylinder, 22 feet long and 5 feet in diameter, with hollow trunnions at each end, through which the pulp to be ground passes in at one end and out at the other. The trunnions rest on solid bearings and the cylinder is revolved by a pulley at a speed of 38 revolutions per minute. The cylinder is lined with chilled steel, and inside seven tons of the hardest flint pebbles are placed. The pebbles are about the size of a tennis ball, and the rounder the pebbles the better. One such mill can deal with the coarse product from 20 stamps crushing 10 tons per diem each. It is estimated that the tube mill will enable the mill capacity to be doubled at the cost of £2,000 per 20 stamps, or £10,000 to £12,000 per 100 stamps, plus the extra cyanide plant and the cost of something less than 40 h.p. per 20 stamps. Many of the leading groups are now erecting these secondary crushers.

The high altitude of the Rand has rendered the question of water supply of first importance. The mines relied upon reservoirs for the collection of a sufficient supply during the rainy period to carry on mills and cyanide works throughout the dry season, the Johannesburg Water Works doing its best to meet the frequent deficiencies. But the Transvaal Government appointed an investigating Commission in 1901, and in May, 1903, a Water Board was established. The undertakings proposed to be acquired were the Johannesburg Water Works, the Vierfontein, Braamfontein, and Wonderfontein Syndicates. The last-named was, however, omitted, as it was thought that otherwise the irrigation of the Potchefstroom District might suffer. The Rand Water Board issued £3,400,000 4 per cent. inscribed stock in March last. The Board supplies towns in bulk. The mines are supplied through mains laid along the Rand by the Board at the rate of 3s. 6d. per 1,000 gallons, and 3d. less where not less than 300,000 gallons per day are consumed. The rate is not cheap for mines, but when it gets much beyond its present daily consumption of two million gallons, a reduction will be possible. The mines, of course, will not draw upon it until their private reserves in dams, &c., are exhausted. The advantage is that no stopping of mills need be feared now, for it is estimated that about 10 million gallons per diem can be obtained from the undertakings acquired.

From the above survey of the Transvaal gold mining industry its magnitude may be gathered and an idea obtained of one of the most exact industrial organizations of the world.

South Africa as a Health Resort.

THOSE who have visited South Africa, and made any prolonged stay there, can hardly fail to be sensibly impressed with its possibilities as a health resort.

Medical men when ordering a "change," recognise that the human constitution requires—above all things—to be subjected to the effects of *contrast*. In recommending the South African continent, this desirable end is achieved in the contrasts afforded by a voyage to a distant land, by climate, scenery, and inhabitants; a series, making for a cumulative restorative effect.

Climates are classified as follows:—(1), Climates of the sea-shore; (2), Mountain climates; (3), Desert climates; (4), Ocean climates. South Africa itself partakes of the first three; and the invigorating influences of the last-named may be enjoyed on the voyage thither.

(*a*) The climate of the sea-shore of South Africa is best experienced during the winter months, commencing in April and ending in September; during these months (in Natal) the season is dry. The climate is warm, temperate, sub-tropical, sometimes cold; the warmth, often of a humid nature, and for that reason is, in consequence, more enervating than the South African continental climates; yet it has its ozonic-tonic properties. The health seeker will derive great benefit from a stay at Durban, Port Elizabeth, or even Cape Town, and at the same time be able to indulge in easy journeys into the interior of the country, where the air is more rarefied by reason of the higher altitude. The best hotels are expensive, but the interests of visitors are well cared for.

(*b*) The term "mountain climate" applies to all elevations between 3,000 and 6,000 feet. Ranging between these heights are the steppes of Natal, extending in a series of gradually rising terraces from the sea, and ending in the majestic peaks of the Drakensberg Mountains, the high veld of the Transvaal, extending to the Magaliesberg Mountains, and the higher tableland, having the township of Middelberg as a centre, and terminating in the north at the mountains round Lydenburg. Nestling at the feet of these mountains, and scattered about the kopje-dotted veld, are the homes of the Boer farmers. The mountain peaks reach as high as 12,000 feet. The climate of the steppes, high veld, and tableland, is never at any season too warm, when living in houses, and is generally dry during the winter months. In winter-time the

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air is crisp, clear and invigorating, and the power of the sun pleasant. The nights are cold, as many as 20 degrees of frost having been recorded. In summer at no time is it insufferably hot. Persons afflicted with an hereditary tendency to consumption, or those suffering from overwork in business, will find these "mountain climates" promise a return to health. The therapeutic elements of a good climate are these, viz., abundance of sunshine without excessive heat, allowing of an open-air life all the year round, pure air, and a temperature adapted to the requirements of the invalid. To these essentials may be added the inestimable boon of necessarily conforming to and living the "simple life."

(*c*) If the characteristic essentials of a desert climate are advocated, consisting of warmth, dryness, purity of air, and large radiation, these are found in the expanses of the Kalahari Desert and Great Karoo. Probably no country is to be found where an outdoor life is so practicable winter and summer as in South Africa, and in which the traveller will find greater variation of or more majestic scenery. The seeker after health, who owns a fair amount of muscular power and activity, will find a long trek in a well-provisioned ox-waggon, say, through Natal to the Transvaal, a sure guide to the restoration of full mental and bodily vigour. The features of the scenery encountered are among the most sublime in Nature, while strikingly distinct from that of other lands.

NOTES.

Gold-mining and Labour.

WHEN the South African war broke out (October, 1899), 6240 stamps were providing employment for over 110,000 natives, and gold was being produced at the rate of £20,000,000 per annum. Three companies restarted milling in May, 1901; but at the end of 1903 only 64,000 "boys" were at work on the Witwatersrand, and only 4360 stamps were crushing, out of a total of 7145 erected. The latter were capable of employing 142,000 "boys" under the best economic conditions, while 30,000 more were required for mines merely in the development stage. There was, however, a proved deficiency of 108,000 natives, and moreover it was estimated that within the next five years a total of 11,000 stamps additional to those then existing might be erected. The Labour Importation Ordinance came into force May 19, 1904, and the first shipment of Chinese as mine-workers arrived at the New Comet Mine at the end of June, 1904. From the details supplied by members of the Transvaal Chamber of Mines and other companies it was shown that unskilled native labourers in employment at the end of 1904 numbered 77,014, and Chinese coolies (indentured) 20,396. These, with about 2000 Cape "boys" and Indians, made up a total of 99,623. The numbers at work on the 31st of May last were: Natives, 96,226; and Chinese, 40,117. At the end of December, 1904, the skilled and unskilled white labourers at work on the surface or in the mines numbered 14,173, and the wages bill came to £4,337,256. At the beginning of June, 1905, the number so employed was 16,626. On the Rand alone 5555 stamps were in operation at the end of December, 1904, and during the whole year 8,058,296 tons were crushed, the yield from the mills, cyanide and other reduction works being 3,658,241 ozs. of fine gold, of a total value of £15,529,219, or 38·46 shillings per ton crushed. In April, 1905, 6665 stamps were in operation in the whole of the Transvaal, and a tonnage of 929,268 was milled for a yield of £1,695,550, as against a monthly average of £1,337,900 in 1904. The total production in the Transvaal to the end of May amounted to £132,765,870; for 1904 the total was £16,054,809, or more than one-fifth of the world's production during the year, estimated at £71,898,713.

Big Game Extermination.

THE greater part of the country which will be visited by the members of the British Association possesses special interest for the naturalist from the circumstance that it was once the home of a multitude of big game animals, the like of which was unknown in any other part of the world's regions within the historic period. Their numbers, however, have been decimated through the avarice or improvidence of civilized man, aided in some measure by the native races, following their acquirement of and subsequent familiarity with the use of fire-arms. Within modern times the tract of country in South-East Africa where these big game animals abounded most was probably the plains of Bechuanaland, the Orange River, and the Transvaal, parts of which formed the hunting-ground of Gordon-Cumming and other pioneer sportsmen, but earlier the plains of Cape Colony were populated by a vast fauna of large and beautiful game animals. At the commencement of the Dutch occupation we read of white rhinoceroses being met with quite close to Cape Town. The Dutch, however, were not long in perceptibly decreasing the number of big game in the country; and one beautiful species of antelope, the bluebuck, or blaauwbok, seems to have been exterminated at a very early date. But some excuse for the vigorous efforts of these Dutch pioneers to thin out the animals which occurred in such swarms in the newly-colonised country may be found, for about the middle of the 17th century we read of their gardens being raided by elands and kudus, and their larger crops destroyed by the incursions of rhinoceroses and hippopotamuses; while on one occasion a slender garrison was actually in fear of the fort being stormed by a frontal attack of lions. Gradually the game was driven further and further up country, though a sufficient percentage remained for the sportsman and naturalist. It was not till after 1837 (twenty-two years prior to this the explorer Burchell had crossed the Orange River and entered Bechuanaland) that the Boers trekked to the districts now known as the Orange River Colony and the Transvaal, and, once there, the fierce pursuit of the game, which, as we have seen, had taken place in Cape Colony, was repeated, but at a more rapid rate, owing to improvements in fire-arms, and the operations of the "skin-hunters," who shot down the animals by tens of thousands, prompted by the commercial uses to which their hides could be put. Between the years 1840 and 1875 the destruction of animals in the old republics, it is safe to say, might be reckoned by millions. According to report, in the year 1860 one specially notable "drive" was instituted, and for this occasion some 25,000 head of game were enclosed, of which it was computed that upwards of 6000 were slaughtered. The settlers realised the market value of the herds of big game with which the veld of the Orange River Colony and the Transvaal was at that time swarming, and took full advantage of their opportunities. By about 1880 a clean sweep of the game had been made, and to-day one may wander over those same plains which, in Gordon-Cumming's time, were actually blackened by the presence of roaming animals, without seeing even a single herd of game, or, at most, nothing more than a few springbok as survivors. Nor was the destruction confined to skin-hunting; ivory was an even more valuable commodity, and so keen has been the pursuit that there are now but few districts remaining where elephant-hunting for profit can any longer be regarded as practicable.

From Cape Colony to the Transvaal the effort is too late for effective game preservation, and all that can be done is to preserve the scattered herds of the surviving rarer species till such time as they perish from in-and-in-breeding. In Rhodesia and other neighbouring districts the outlook is more hopeful, and whatever is possible under existing circumstances is being done to ensure the preservation of a portion at least of the game. As colonisation and civilisation spread, the wild animals of the country will inevitably tend to disappear, and, however unwillingly, we must face a time when, notwithstanding international co-operation, a large portion of Africa will be as destitute of big game as are the more frequented districts of Cape Colony and the Transvaal at the present day.

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